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EDITORIAL

CONSERVATION is world-wide in scope. Its need is recognized by practically all governments; by farmers and their leaders everywhere; by labor; by industry and commerce; and by the professional interests of all lands. This concern is real and is closely related to the current food needs throughout the world.

Estimates indicate that on a world-wide basis there are only two acres per person of productive agricultural land available. In the United States the figure is three and one-half acres per individual. These estimates take into consideration all lands that are now or may in the future be conditioned for food production purposes. Add to this a rapidly increasing population and we find the acreage of land available per person becoming less. Here in the United States the pressure on the land resulting from increased demands to produce more food for a hungry world will lower the three and one-half acre average. It will also have a tendency to further deplete our soil and water resources.

All this raises several pertinent questions. Are we as a people cognizant of the need to speed up the establishment of conservation practices on the land to offset population pressures and the increased demand for food from other nations? To what extent have farmers adjusted their farm management plans to better utilize increased crop yields, improved pastures, and woodland products? Maximum efficiency in agriculture cannot be achieved unless a practical farm management program is made a continuing part of the accepted conservation farm plan.

The need for a conservation management program is apparent. Its importance is recognized by supervisors of soil conservation districts, by leaders in farm management, and other groups. Farmers confronted with this problem find that methods and techniques required to do the job have been slow to develop. A few widely scattered states, however, are working on the problem. The opportunity to develop a method of procedure that will better utilize increased returns from conservation farming and other agricultural practices is indeed great. This also applies to the need for improving the efficiency of the individual farm unit and agriculture in general.

Consideration should also be given to the development and application of new conservation and farm management techniques on watershed areas or in communities that embrace a group of farms. Problems resulting from conservation farming that are common to these areas may include general shifts in land use, new crops that are more suitable to the land, inadequate marketing facilities and other economic and social adjustments. Many of the same general principles, however, that need to be outlined for an individual farm would also apply to problems that are common to watershed areas or communities. Some additional techniques to properly relate conservation and management that are broad in scope are needed.

The professional conservationist is directly concerned with these needs. He, too, is interested in a practical plan that will properly relate conservation to farm management. This suggests that the Soil Conservation Society of America, in cooperation with other groups, should give consideration to the development of a conservation-management method of procedure that is based on the needs of the individual farm and definite watershed areas. It is a big task and the responsibility rests with the many groups, including the farmer, that contribute to the problem.

Conservation in Foreign Lands

A stimulating article entitled "*Soil Conservation — Nation's Foremost Need in India*" appears in this issue of the JOURNAL. It presents some excellent background data on the need for conservation, kinds of practices that are being planned and established on the land, and how the leaders of that country are organizing a nation-wide conservation program based principally on watersheds.

Forest Hydrology in the Appalachians

E. N. MUNNS

"The lumberman, the forest fire, and the farmer cooperate in the work of forest destruction and the consequent disturbance of the regularity of the flow of the streams. This increases the floods which destroy the valley lands below, and as the irregularity of their flow increases, the streams lose their value for water power during the dry season, and during the season of rain the floods wash away the farming lands in the valleys and carry destruction along their course to the lowlands. As the rains wash away the cleared fields on the mountain slopes and the farming lands in the valleys, these soils on their way toward the sea incidentally silt up the river channels and the harbors. Hence it is strictly true that in destroying forests these agencies are removing the soils, ruining the rivers, and destroying the mountains themselves: and along the lower courses of these streams they are thus destroying agricultural and manufacturing interests, and incidentally seriously affecting important navigation facilities." (1)

THE WATER problem of the Appalachian region is primarily a forest problem. This dependent relation was recognized as clearly by the geologists, hydrologists, and foresters of nearly 50 years ago as it is acknowledged by conservationists today. Both problems are well on their way to solution.

Great progress has been made in solving the southeastern forestry problem during the past half-century. Much steep land has been publicly acquired, automatically retiring from further abuse many thousand acres of "worn-out agricultural land." Forest fire control has been applied in varying degree to nearly all woodland. Logging practices that result in denudation over large areas of mountain land are seldom seen. Many denuded and open lands have been reforested. Woods grazing is less widespread. Roads and highways are more carefully located and many roadsides are being revegetated. (2) Many sore spots still exist, but they are not as extensive as before. Although conservation measures are not as widely applied as they should be, they are generally accepted and cover conditions on many forest lands show marked improvement over the earlier conditions.

Water Resources Are Improved

Improvement in water has gone hand in hand with the adoption of these forestry measures. Streams that once were heavily discolored by their loads of soil, now flow clear. Stream channels, once lined with great banks of loose sand and gravel lying naked in the sun, are now shaded and tree-clothed and the debris is anchored in place by myriads of tree roots. Flood peaks have been reduced as rapid surface runoff has been checked and in consequence a greater regularity in flow has been achieved. However, floods, irregular flows, water shortages, and other less important water problems remain with us in varying degree. Although advancement in the solution of the over-all water problems has been achieved by the general adoption of forestry practices, what further is needed? One answer is the adoption of that type of forest management which will adequately take water values into account.

MR. MUNNS is Principal Silviculturist in Charge, Forest Influences, Forest Service USDA, Washington, D. C. This is the first in a series of two articles on Forest Hydrology. The second article is scheduled for the July issue of the JOURNAL. Mr. Munns' article presents an analysis of certain data obtained from a series of experimental watersheds.

The idea of intensive forest management in the interest of the water resource is startlingly new. It came about with the realization that geology, soils, topography, precipitation, climate, forest types and the uses of the forest land all affected water in some way. It also resulted from the growing realization that to achieve a reduction in floods, practices different from those used to obtain maximum yields of domestic water must be followed. As facts to substantiate the idea were lacking and in order to understand how the various factors could be integrated, to discover their values in relation to water flow, and to develop methods applicable in forestry, research was needed.

Research was especially needed in the Appalachian forest area from the Potomac to the Coosa. Water values in this area were increasing. Available supplies were dwindling. Industrial, municipal and domestic demands were growing. Abundant water was needed for recreation. Cheap hydroelectric power was attracting new industries and people. Damages per unit of flood discharge were increasing. Forests were recovering from heavy exploitation. Accordingly, studies of forest and water relations hydrology were included in the research program of the Southeastern Forest Experiment Station at Asheville, N. C., in the late 20's.

SOIL AND WATER PROBLEMS WERE INVESTIGATED

Early investigations here were directed to an understanding of some of the basic soil and water problems. Among the first were those to determine the amount of precipitation which reached the ground with storms of different characteristics and intensities, and under various types, densities and ages of forest cover. Studies of the litter were made. Some of the early ones revealed that even the gentle removal of the forest litter by whatever means as by raking and without disturbance to the soil resulted in markedly reduced infiltration and increased surface run-off. (3) For example, a 10-minute quarter-inch rain with intensities of 3 inches per hour produced 20 times the volume of run-off from the raked plot as the natural plot, the rates being also in the ratio of 10 to one.

Other studies revealed that agricultural soil resembles an unorganized mass of building materials whereas the natural forest soil with its stable organization is more like a house built from this material. Primary aids in this building are the inhabitants of the soil—the myriads of microarthropods which digest the litter and incorporate it as humus in the soil. (4) The number of these microorganisms varies greatly with moisture and plant food, from one square inch to another, and diminishes with increasing soil depth from 1,800 at one- or two-inch depths to 130 at a foot depth per square foot of surface. These and other small animals according to their diminishing abundance are mites, springtails, ants, hemiptera, myriapods, thrips, beetles, and a miscellany of others. Earthworms (not microarthropods) are found in abundance, but some species of worms are so exceedingly minute as not often to be discovered. The larger species are usually found in mull soils. Loss of surface litter and exposure of the mineral soil as by fire, grazing or logging, and the slight erosion of the top soil eliminates many of these soil makers.

PROBLEMS ARE RELATED TO WATERSHEDS

Associated with these basic studies were others of small watersheds on the Bent Creek Experimental Forest near Asheville. One comparative study over an 8-year period revealed that the peak discharge from a wooded area for storms with a maximum intensity of 1 inch in 20 minutes did not exceed 25 c.f.s. per square mile. The comparable peak discharge over a two-year period for a nearby area in weeds was 275 c.f.s.; in the next two-years when the area was lightly grazed, the discharge was 615 c.f.s.; in the next two-year period with added grazing use, the discharge soared to 1,000 c.f.s. An application of lime and phosphate was given the area which was put into lespedeza. The discharge rate for the next two-year period dropped to 150 c.f.s. These comparative studies revealed the need for more detailed forestry investigations. (5) Accordingly a new area was sought where

Figure 1.—Not all rain and snow falls directly to the ground; some of it is held temporarily on the branches before dripping to the ground; some runs down the trunk. Foresters must determine the amount of this stem flow to account for all the precipitation which reaches the ground.

the whole gamut of forest conditions could be studied. A suitable area of 5,000 acres was found in the drainage of Coweeta Creek near Franklin in southwestern North Carolina.

The Coweeta Experimental Forest is high in the mountains of North Carolina and only a stone's throw from Georgia and Tennessee. Physical conditions appear virtually perfect for hydrologic studies. It has some 50 storms per year producing an annual rainfall of around 80 inches, deep (up to 30 feet) well drained granitic soils on unstratified rocks with well stocked, unburned and ungrazed forests at elevations between 2,000 and 5,500 feet, and a topography that produces many small individual drainages each with its own living stream. And, not far away are the smelter-denuded Copper Basin and the Bent Creek and Enoree Experimental Forests, each affording other opportunities for supplemental investigations with different soils, geology, rainfall, and forest conditions.

In making Coweeta into an outstanding hydrologic laboratory, the first step was to learn as much as possible about hydrologic conditions. A complete set of 67 precipitation stations was installed along trails constructed throughout the main area. Precipitation caught in the standard cans was measured after every storm and checked with 12 intensity gages. Coincidentally, 27 stream-gaging stations were installed, 21 on small independent watersheds, and the balance on reaches of the two main forks. The main gages are supplemented by shallow wells at which the fluctuations in depth and flow of ground water can be determined. Ground water wells and meteorologic stations were also installed at the headquarters station and within some of the smaller watersheds. Other hydrologic data relate to water quality, frost, snow, evaporation, etc. An inventory of soil and forest conditions was also made.*

Original plans provided for a standardization period of 10 or more years before any treatment was accorded a watershed. The gages had been in operation only a short time when it was discovered that because of the uniformity and number of storms per year, the stream behavior was rather uniform basin by basin, storm by storm, and season by season. This permitted each stream to be compared with itself, and shortened the time required for standardization to around 5 years.

The scheduled treatments were designed to furnish information on how the forest cover affects water production, behavior and rate of discharge. With information on these matters available, specific forestry practices could be developed for drainages where flood control is the objective, for those where water yield is important, or for those where regularity of flow is desirable. It will also be possible to determine how, when and under what conditions the forest can be harvested or the land utilized to pro-

*Dryman's Fork drainage of 1,500 acres has not yet been developed.

duce desired streamflow.

The forest treatments included such practices as the continual removal of all timber growth from one watershed without soil disturbance; maintaining a "brush" cover on another clear-cut area; cutting as done by local loggers; cutting and logging according to silvicultural needs and according to watershed considerations; cutting of riparian vegetation; mountain grazing; forest burning; changing forest to agriculture; etc. (6) Several of these treatments were put into effect prior to World War II.

WATERSHEDS ARE SELECTED FOR TREATMENT

Two small watersheds (33 and 40 acres) have been cut clean. All vegetation down to broomstick size was cut to the ground with none of the wood material salvaged. Care was taken not to disturb the litter or the soil. The effect on streamflow was electrifying: the run-off the first year was increased by 17 area inches or 65 percent. During the summer the low water flow was increased from a calculated 3 inches to over 7. At no time during the year was there a significant increase in storm flow or a change in water quality. On the one watershed where a new sprout forest is developing, a gradual reduction in the water yield is noticeable.

Cutting in another small basin (22 acres) was confined to the riparian forest. Again no logging or other disturbance of the forest soil was permitted. Although the cutting was limited to the small area closely adjacent to the stream and amounted to only 12 percent of the drainage, the increase in stream flow was about 20 percent. Again, water quality was unaffected.

A 212-acre watershed is being logged. Cutting and logging are being carried out according to the ideas of the mountain operator. He cuts what trees he wants and gets the logs out in any fashion that appeals to him. As soon as the area can no longer be logged profitably for lumber, cutting for other products such as posts, pulp and fuel will be permitted. The cutting and

Figure 2.—Within the Coweeta Forest, one experimental watershed was cleared of all of its timber, and was plowed and grazed by the mountain people according to the common local practice. Another watershed, entirely forested (beyond car at left center), is being grazed. Still another watershed (at top right) has been cut over.

Figure 3.—Water is the main product of the Coweeta Forest. How it behaves when the cover is disturbed is written on charts at 32 gaging stations, many of which control small watersheds.

skidding have resulted not only in changes in the stream flow but also in the quality of the water as the stream carried large amounts of soil. Skid trails yielded several times as much debris as had been expected, rendering volume measurements impossible. Further an immediate rise in stream flow occurred as each trail provided an avenue for prompt surface run-off. Erosion continued also throughout periods when logging was shut down because of operational difficulties.

Perhaps the most interesting small drainage is one that was first cleared for agricultural use. After clearing the 23-acre watershed, a local farmer was induced to operate the "farm" according to his own lights. On the "more gentle" 30 percent slopes, he grew corn; on the steeper ones, he grazed cattle. For the first two years water production increased without much damage to water quality, although erosion was evident in the corn field. By the third year, the organic material was largely gone and the soil structure breaking down. Infiltration then decreased. Surface run-off took place with each rain and the peak discharges increased more than 10 times over those recorded before clearing and cultivation. Erosion became generally prevalent and so much soil material was washed out of the drainage that it discolored the main creek for a considerable distance downstream. Although efforts were made to measure the amount of soil lost, the sediments in the first flash floods exceeded the capacity of the silt traps and the maintenance crew. Now that the corn yields have greatly fallen off and gullies developed, the local farmer is indifferent towards further cultivation of the area. He insists now that his equipment is worn out, he has much other work, he's getting too old and doesn't feel so well, and his animals need a rest!

Grazing on a 145-acre watershed is demonstrating the damage livestock can do. Although from a distance the forest cover appears just as dense as ever, the interior of the stand shows

what is taking place. Soil compaction is general. It is worse on the best soils because here the best forage grows. Porosity was reduced more than 10 percent in the first six weeks. The undergrowth of palatable tree seedlings is being wiped out. Then too, with the loss of the under-story, wind is able to get under the crowns of the forest and blow the litter out of the area. Soil compaction and loss of litter are steps towards eliminating the beneficial effects of the forest while the land is still covered with trees.

STUDIES REVEAL MANAGEMENT PRACTICES

These Coweeta studies not only have suggested some of the measures to be used in intensive watershed management but they have taught us much about water and forest relations. The mixed hardwood forest of the Appalachian area uses much more water each year, especially in the growing season, than anyone realized. Whether this water was actually needed for growth or whether the forest uses it merely because it was available remains to be worked out. Removal of the vegetation reduced this transpiration draft and provided more water for run-off. So long as the soil and its humic cover are not disturbed or lost, this does not cause floods. Possibly this is untrue for other areas even in the same region.

Soil disturbance when associated with stand treatment changes the picture. Logging provides numerous compacted skid trails becoming focal points for surface run-off and erosion. Livestock also compact soils and when associated with litter removal, similarly provide opportunities for stimulated run-off and attendant erosion. Compaction by livestock is unlike that by other agencies in that stock are more or less constantly in motion over the whole area on a 24-hour basis. This fact places stock at the top of the list of all soil compacting agencies.

The study of mountain agriculture at Coweeta shows that soil structure must be maintained if such cultivated lands are not destroyed. It is planned to continue the deterioration of this agricultural drainage until some degree of uniformity in run-off and erosion is obtained, after which the effort will be to determine how long a period is required to reestablish a good forest soil. Nature, however, may interfere, as black locust sprouts have already appeared. In other areas, these sprouts have spread and reclaimed mountain farmlands despite efforts to eliminate them.

FLOOD CONTROL DEPENDS ON KIND OF FOREST

The Coweeta studies suggest that for flood control, a dense vigorous water-using forest is highly desirable. By depleting the soil moisture such a forest provides storage during time of storm. In such a forest an excellent litter and humus are formed which provide for a maximum of infiltration capacity. During the growing season, therefore, the forest operates at a maximum in taking care of the storms which sometimes provide heavy precipitation at high intensities.

On the other hand, when water yield is the important item, an increase in flow is indicated if the water-using forest is reduced in density. If we do not wish to remove all the forest, we can take the trees in the valley bottoms and flood plains, for these are gross dispensers of water. By reducing transpiration, industries and communities dependent upon local watersheds may augment their supplies. Studies have not yet reached the point where the "Old Soaks" of the forest, i.e., those species which use abnormal supplies of water, can be identified. Grazing within the hardwood forest area appears to cause more damage to a watershed than is generally realized. Similarly the damage to water quality by agriculture on steep slopes, alone seems sufficient justification for its elimination in important Appalachian watersheds.

Timber harvesting in the Appalachians does affect water adversely. Most of the damage it causes is the result of indifference and carelessness. This need not be so. If roads can be built without excessive damage in hilly lands, then thoughtful planning and careful work during the logging operation should minimize the harm. Then too, the injury from raw soil surfaces can

(*Continued on page* 112)

Economics of Soil and Water Conservation

ELMER L. SAUER

MR. SAUER, while on leave of absence from his position as Project Supervisor of research in the economics of soil and water conservation—a cooperative project between the Department of Agricultural Economics, University of Illinois and the Soil Conservation Service—submitted this paper in partial fulfillment for an advanced degree. He is the author of 48 articles and reports (28 with co-authors) on soil and water conservation problems in Illinois.

THE INTENT of this study was to measure the effect of soil and water conservation on crop and livestock production and on farm incomes in selected areas of Illinois. Data were obtained concerning production, conservation and other operating costs, and incomes on sample farms of similar land use capabilities but with differences in the amount of soil and water conservation practices.

Conservation as used in this study refers to the intelligent use of soil and water resources including the use of land in accordance with its capabilities and the use of practices to lessen or prevent soil and water runoff and erosion and to maintain or improve soil fertility.

Source of data. The data used were obtained from farmers by the survey method, from farm account summary sheets in the files of the Department of Agricultural Economics, College of Agriculture, University of Illinois, and from field records, and soil conservation surveys of the Soil Conservation Service, U. S. Department of Agriculture.

Areas studied. Six sample areas were used: Jefferson County; Madison and St. Clair counties; McLean County; Stephenson, Jo Daviess and Winnebago counties; Northeastern Illinois slowly permeable till soils; and Central Illinois cash grain area. Farms with conservation plans at least three years old and with a large percentage of application of conservation practices were "paired" with physically comparable farms not having conservation plans.

Conservation and management scores. A soil conservation score was computed for each farm based on the degree to which conservation measures needed had been applied to the farm. The farms with conservation plans were labeled, "Farms with High Conservation Scores," and those without conservation plans, "Farms with Low Conservation Scores." . A management score, based on an evaluation of the operator's abilities in livestock management, adequacy of power and equipment, timeliness of field operations, and seed selection and treatment, was computed for each farm.

Costs and Benefits of Conservation

The costs of and benefits from conservation varied from area to area, reflecting differences in soil resources, type of farming, and local variations in weather.

Conservation needs and conservation expense. The farms with high conservation scores spent more per acre for conservation than the low score farms. A higher proportion of the gross income was required for conservation in the poorer land areas (Table 1). The lower level of soil fertility and, consequently, greater needs for limestone, phosphate and fertilizer caused higher conservation costs in Jefferson County.

Crop yields. The crop yield index was significantly higher on the farms with high scores in each of the six areas studied (Table 2). The soil fertility program, improved land use program, and use of practices such as contouring, strip cropping, terracing, tile and surface drainage, etc., accounted for from nine to 21 points increase in crop yield index for the six areas studied.

Livestock production. The farms with high scores produced more meat and milk per acre than the farms with low scores (Table 3).

Net income. The farms with high conserva-

TABLE 1.—CONSERVATION NEEDS, CONSERVATION EXPENSE PER ACRE AND PERCENT CONSERVATION EXPENSE IS OF GROSS INCOME, FARMS WITH HIGH AND LOW CONSERVATION SCORES, BY AREAS.

Item and Area	Farms With High Scores Col. (1)	Farms With Low Scores Col. (2)	Difference Col. 1 Minus Col. 2
Total Conservation Needs Per Acre:			
Jefferson	$22.63	$20.22	$2.41
Madison-St. Clair	17.27	15.78	1.49
McLean	20.98	20.32	.66
Stephenson-Jo Daviess-Winnebago	15.85	14.50	1.35
Conservation Expense, 1945:			
Jefferson	2.10	1.30	.80
Madison-St. Clair	2.00	.96	1.04
McLean	2.33	1.86	.47
Stephenson-Jo Daviess-Winnebago	1.45	1.11	.34
Northeastern Illinois:			
Clarence-Rowe Soils	1.70	1.08	.62
Clarence-Swygert-Elliott Mixed Soils	2.51	2.03	.48
Cash Grain[a]	3.29	1.99	1.30
Conservation Expense, Percent of Gross Income, 1495:			
Jefferson	10.1	10.1	0
Madison-St. Clair	5.2	3.3	1.9
McLean	4.3	3.6	.7
Stephenson-Jo Daviess-Winnebago	3.1	2.7	.4
Northeastern Illinois:			
Clarence-Rowe Soils	4.9	4.5	.4
Clarence-Swygert-Elliott Mixed Soils	6.0	7.3	—1.3
Cash Grain[a]	5.9	4.6	1.3

[a]Five-year average, 1941-45. Includes expense for all capital improvements for land and buildings.

tion scores had significantly higher incomes than the farms with low conservation scores (Table 4).

Jefferson County. Conservation needs in this mixed farming area include fertility improvement, land use adjustment, rotations using deep-rooted legumes, erosion control and drainage. The productivity level and earnings of farms are very low unless a soil conservation and fertility improvement program is applied. Conservation plans made it possible to use the land more productively. The farms with higher conservation scores had in 1945 larger acreages in corn and soybeans, small grains, and legume hay and rotation pasture, and less cropland idle. Low earnings and the consequent lack of capital are major factors limiting conservation in this area.

TABLE 2.—CROP YIELDS BY AREAS, FARMS WITH HIGH AND LOW CONSERVATION SCORES, 1945.

Item and Area	Farms With High Scores Col. (1)	Farms With Low Scores Col. (2)	Difference Col. 1 Minus Col. 2
Crop Yield Index[a]			
Jefferson	110	89	21
Madison-St. Clair	107	94	13
McLean	106	94	12
Stephenson-Jo Daviess-Winnebago	105	95	10
Northeastern Illinois:			
Clarence-Rowe Soils	110	91	19
Clarence-Swygert-Elliott Mixed Soils	108	92	16
Cash Grain	105	96	9

[a]Average yield of all crops for all farms in each area equals 100.

TABLE 3.—UNITS OF LIVESTOCK PRODUCTION PER ACRE BY AREAS, FARMS WITH HIGH AND LOW CONSERVATION SCORES, 1945.[a]

Item and Area[b]	Farms With High Scores Col. (1)	Farms With Low Scores Col. (2)	Difference Col. 1 Minus Col. 2
Pounds Meat Plus 10 Pounds Milk Per Acre:			
Jefferson	103	74	29
Madison-St. Clair	174	124	50
McLean	272	216	56
Stephenson-Jo Daviess-Winnebago	280	247	33
Northeastern Illinois:			
Clarence-Rowe Soils	112	59	53
Clarence-Swygert-Elliott Mixed Soils	153	58	95

[a]One pound of meat or 10 pounds of milk is used as a unit of livestock production.

[b]These data were not available for the cash grain area.

TABLE 4.—NET INCOME PER ACRE BY AREAS, FARMS WITH HIGH AND LOW CONSERVATION SCORES, 1945.

Area	Farms With High Scores Col. (1)	Farms With Low Scores Col. (2)	Difference Col. 1 Minus Col. 2
Jefferson*	$20.80	$12.97	$7.83
Madison-St. Clair	14.60	6.29	8.31
McLean	27.51	22.64	4.87
Stephenson - Jo Daviess-Winnebago	21.33	13.86	7.37
Northeastern Illinois:			
Clarence-Rowe Soils	14.39	6.39	8.00
Clarence-Swygert-Elliott Mixed Soils	18.92	10.60	8.32
Cash Grain	32.19	25.54	6.65

*Gross income for Jefferson County; net income for all other areas.

Madison-St. Clair counties. Major conservation problems in this wheat, dairy and poultry farming area are fertility improvement, erosion control and drainage. Farm account records were used and the level of management was above the average for all farms in this area. The farms with high conservation scores had a higher proportion of their land in hay and pasture (particularly legumes) and a lower proportion in small grains, intertilled crops and idle. Wet weather in 1945 operated to widen differences in earnings. The high conservation farms, with more and better quality pasture, had higher livestock production and were not affected so adversely by the wet weather.

McLean County. Sheet and gully erosion and drainage problems, resulting in large part from continuous cropping with soil depleting and intertilled crops which have depleted organic matter and available soil fertility, constitute a major conservation problem in this area. The farms used represent better than average management and application of conservation practices. The high score farms had a slightly higher proportion of their cropland in deep-rooted legumes and a smaller proportion in intertilled crops. The major difference in conservation on the two groups of farms was in the application of conservation practices such as contouring, terraces, grass waterways, surface drainage, use of rotations with deep-rooted legumes and other practices which involve little, if any, extra cash cost. The high conservation score farms in McLean County were using their land more intensively than normal due to the wartime demand for corn and soybeans, therefore, the differences between the two groups are not as pronounced as for high and low conservation groups in the other areas.

Stephenson, Jo Daviess, and Winnebago Counties. Erosion control and fertility improvement are major conservation problems in this area. The farms with high scores had a higher proportion of their land in hay and pasture, particularly legumes, and a lower proportion in small grains and idle. Increases from contouring, strip cropping, terracing, grass waterways, surface drainage, and pasture improvement demonstrate the increases in production and income that conservation and good management make possible.

Northeastern Illinois Slowly Permeable Till Area. The slowly permeable till soils have a heavy plastic subsoil which impedes the normal movement of water, causing serious erosion on the sloping areas and poor drainage on the level areas. In addition, these soils are generally acid and low in phosphate. In general, the area has been intensively cropped and both organic matter and fertility are low. The Clarence-Rowe soils in this group are more nearly impermeable and erosion and drainage problems are generally more serious for those soils than for the mixed Clarence-Swygert-Elliott soils. In both the Clarence-Rowe and the mixed Clarence-Swygert-Elliott groups the farms with high conservation scores had significantly higher returns. These higher earning farms had a higher proportion of their land in deep-rooted legumes and a smaller proportion of their land in soybeans. They had applied more phosphate and limestone, produced more livestock and applied more manure. The farms with high conservation scores represent better than average management, while the farms with low scores probably represent close to average management for this area.

Cash Grain Area of Central Illinois. Comparisons here were made between "matched" farms grouped according to proportion of land in legumes in nine central Illinois counties. Land use adjustment is the major problem of conservation in the area. On many farms corn and soybeans account for as much as 75 percent of the tillable land, small grains another 10 to 20 percent, leaving only a small proportion in deep-rooted legumes. The study centered around a comparison between farms having less than 10 percent of their tillable land in legumes and physically comparable farms having 20 percent or more of their tillable land in legumes. Data were based on the five-year average, 1941-45. The farms with the most legumes had a higher percent of their tillable land in corn but a smaller percent in soybeans. They had 48 percent of their tillable land in these two crops, compared to 65 percent for the farms having the least legumes. Legume acreage averaged 23.6 percent for the former group and 7.3 percent for the latter group.

Long-Time Benefits from Conservation. Yields and income are increasing on the farms with high conservation scores relative to the farms with low scores, as observed in three areas in which long-time farm records were available on identical farms (Table 5).

TABLE 5.—YIELDS AND INCOME ON IDENTICAL FARMS FOR TWO PERIODS, BY AREAS, FARMS WITH HIGH AND LOW CONSERVATION SCORES.*

	Crop Yield Index		Net Income Per Acre	
Area and Years	Farms With Low Scores	Farms With High Scores	Farms With Low Scores	Farms With High Scores
Madison-St. Clair				
1939	100	100	$ 9.87	$ 9.84
1945	107	94	14.60	6.29
Stephenson-Jo Daviess-Winnebago				
1940	98	102	12.46	12.91
1945	105	95	21.23	13.86
McLean				
1936	97	103	5.78	6.54
1946	106	94	27.51	22.64

*Conservation scores as computed for the year 1945.

SIGNIFICANCE OF COMPARISONS BETWEEN CONSERVATION AND MANAGEMENT

Cross tabulation analyses indicated the relative influence of conservation scores and of management scores as used to be as shown in Table 6. Limits on the significance of these are discussed in the following paragraph.

TABLE 6.—PROPORTION OF THE DIFFERENCE IN INCOME AND YIELDS BETWEEN HIGH AND LOW CONSERVATION FARMS THAT MAY BE ATTRIBUTED TO CONSERVATION AND TO MANAGEMENT OTHER THAN CONSERVATION.

	Yields		Income	
Area	Percent of Difference Attributed to Conservation	Percent of Difference Attributed to Management	Percent of Difference Attributed to Conservation	Percent of Difference Attributed to Management
Jefferson	60	40	76	24
Madison-St. Clair	87	13	73	27
McLean	62	38	64	36
Stephenson-Jo Daviess-Winnebago	72	28	70	30

The validity of the conclusions to be drawn regarding the relative effects of conservation and management depends in part upon how well the two scores actually measured conservation and management other than conservation. It is the writer's opinion that the conservation score was adequate and satisfactory. However, the writer recognizes that the management score may have been inadequate. An analysis of farm account data for one of these areas indicates that if four management factors (1) corn yield, (2) horse and machinery efficiency index, (3) labor efficiency index, and (4) livestock efficiency index had been used as a measure of management, 55 percent of the differences in earnings per acre would have been accounted for by conservation and 45 percent by these management factors instead of 70 percent by conservation and 30 percent by management as shown in this study (Table 6). It is probable that the importance of conservation might have been similarly reduced in other areas if an

objective management score had been used.

In areas in which data were based on surveys, it was not possible to obtain data which permitted objective evaluation of management. Although management data could have been derived from records in other areas, the same management score based on opinions was used in order to have uniformity throughout the study.

Another qualification necessary in interpreting the tables reporting the relative effects of conservation and management is that in grouping the farms for these tables, they were shifted without regard to comparability of soil resources and so the identity of land use capability maintained in the direct comparisons of high and low conservation farms was lost. Some of the differences found may be explained by this fact.

Because of small samples the data were grouped in these tables into four groups with equal numbers in each group, the dividing points being the high and low half for each factor. Because of intercorrelation between the two factors this method caused the differences between the groups to be affected by differences in averages for both factors rather than in only one. This may have reduced the validity of the conclusion as to the relative influence of conservation and management on earnings and yields.

Early in this study it was recognized that management other than conservation was an important factor affecting farm earnings. The writer believes that the management score could be improved and recommends that in subsequent studies a technique for measuring management be formulated from the data obtained rather than drawn subjectively from opinions of informed observers. However, the evidence is sufficiently strong to support unquestionably the conclusion that conservation is a most important factor influencing the level of farm earnings.

CONCLUSIONS

Farms with high conservation scores tended to follow a complete conservation plan, including (1) testing and treating the soil, (2) using the land according to its capabilities, (3) using rotations with ample acreages of deep-rooted legumes, and (4) using proper water disposal practices, such as grass waterways, contouring, strip-cropping, terracing, tile and open-ditch drainage where needed.

Conservation farming increased crop yields by 9 to 21 percent in the six areas studied. Both higher yields and the larger acreages of better pastures caused the high conservation farms to produce more total digestible nutrients, and this resulted in higher livestock production on such farms than on the low conservation farms. The higher production on the high conservation farms is reflected in higher incomes. Differences in net farm incomes per acre for high and low score farms varied from $4.87 in McLean County to $8.32 in the mixed soils area of Northeastern Illinois. In addition to increasing current income conservation prevents soil erosion and the loss of capital resources, and thus leaves the farm more productive.

At 1945 price levels, a high conservation farm of 160 acres would have earned above a low conservation farm:

Jefferson County	$1,254
Madison-St. Clair Counties	1,330
McLean County	779
Stephenson-Jo Daviess-Winnebago Counties	1,179
Northeastern Illinois: Clarence-Rowe Soils	1,280
Mixed Clarence-Swygert-Elliott Soils	1,331
Cash Grain Area of Central Illinois	1,064

The increased incomes on the high conservation score farms would have been significant, even at the 1935-1939 level of farm prices. At 1935-1939 prices the earnings of an 160-acre high conservation farm would have exceeded earnings on a low conservation farm by:

Jefferson County	$732
Madison-St. Clair Counties	778
McLean County	456
Stephenson-Jo Daviess-Winnebago Counties	689
Northeastern Illinois: Clarence-Rowe Soils	749
Mixed Clarence-Swygert-Elliott Soils	779
Cash Grain Area of Central Illinois	622

Annual conservation costs in 1945 on an 160-acre high conservation farm would have exceeded costs on a low conservation farm by:

Jefferson County	$128
Madison-St. Clair Counties	167
McLean County	76
Stephenson-Jo Daviess-Winnebago Counties	55
Northeastern Illinois: Clarence-Rowe Soils	100
Mixed Clarence-Swygert-Elliott Soils	77
Cash Grain Area of Central Illinois	160

Differences between earnings of conservation and non-conservation farming as measured by the differences between farms with high conservation scores and farms with low conservation scores are gradually becoming wider. The farms with high conservation scores are maintaining or increasing their production and income relative to the farms with low conservation scores, upon which yields, production and income are diminishing.

The costs of a complete conservation program are high, varying by areas from $15.85 to $22.63 per acre. In 1945, farms with high conservation spent on the average in different areas from 3.1 to 10.1 percent of their gross income for conservation. A higher proportion of the gross income was required for conservation in the poorer land areas.

Increased earnings were not immediate, and considerable time and money were expended before such positive results were achieved. The high conservation score farms used in these comparisons have had plans in operation from one to eight years. Some of the benefits of conservation, such as yield increases from contouring, show up the first year, but increases in yields from applications of limestone generally do not show up until the rotation has gone through a complete cycle and a crop of clover or other legumes has been plowed down.

Farmers are interested vitally in the economic returns from their farm businesses. Before they make changes, they ask "Will it pay?" The longtime benefits of conservation are positive. Comparison of farms having complete conservation plans with neighboring, otherwise comparable farms show that the conservation farms had more land in legumes and grasses, had higher crop yields, produced more and better quality hay and pasture, fed more livestock, had higher livestock production and returns, and secured larger net farm incomes. Sound conservation programs provide income for the needs of today and a heritage for the needs of tomorrow.

Some Facts About Soil Moisture and Drainage

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THE QUESTION of water supply for plant growth, farm wells, and industrial use is of interest to many these days as reports of water scarcities in some quarters keep pace with reports of too much water in others.

The drainage problem frequently is an important phase of operations undertaken in soil conservation districts. Agencies such as the Soil Conservation Service assist farmers in its solution through technical assistance with the application of soil conservation practices, including drainage, and the loan of ditching equipment. Considerable of our most fertile corn belt soils become productive and thousands of acres of our drained land have been settled into wealthy farm communities through drainage enterprises. It must be recognized that the individual farmer on drained land is entitled to protect and maintain his investment.

Drainage contributes to good land use and to improved soil and moisture conservation. The annual flooding of bottom lands not only destroys crops but often forces the farmer to use steep slopes for cultivated crops in order to maintain sufficient production for needed farm income. If wet bottom lands, not usually subject to erosion, are drained, relatively high production of cultivated crops may be obtained on them. Sloping, erodible fields may then be protected and kept productive in pasture, meadow or farm woodland. These low lands may be drained by field tile systems connected with tile outlet mains or drained directly into open ditches. In some areas open ditch drainage alone is used.

Farmers Are Interested in Soil Moisture

In various farming areas individuals or groups of farmers and sometimes representatives of various agencies contend that drainage, tile or ditch, is robbing the surrounding farm lands at higher elevation of soil moisture and thus causing loss of crops and production through creation of drouthy conditions. This argument is advanced regardless of soil type, classification, or difference in elevation between bottom lands and higher lands. The proponents of this argument in many cases try to base their case upon sciences with which they are unfamiliar while disregarding the natural evidence on which there is some basis for judgment.

Most of the arguments, many of them unsound, refer to "ground water supply" rather than to "soil moisture" which in these cases is the water the farmers are particularly interested in.

Ground water is the common designation among technical workers for water that has already percolated beyond the reach of plants. This is the water far down in the soil which feeds wells. It may be in the nature of underground streams, saturated strata, or even underground lakes. But in any case, it does not feed the plant growth on the surface.

Soil moisture on the other hand is the moisture retained in the top soil and the sub-soil immediately below which is in proximity to plant roots and available for use by plants.

We are not attempting to discuss ground water in this article. We'll leave that to the geologists and hydrologists, but we do hope to develop some facts about soil moisture, which is what most farmers are thinking about in relation to drainage improvements. Having a clearer understanding of the nature of soil moisture

Figure 1.—The bottomland farmer is entitled to the protection of his investment. This field will be drained.

supply leaves the farmer, by nature of his experience and observations, better qualified than most others to pass judgment on the effects of any particular drainage project.

Many of the most voluble opponents of drainage seem to believe that moisture moves in the soil against the pull of gravity for relatively great distances, both laterally and vertically, somewhat as oil moves up a wick or ink in a blotter. Actually water moves relatively short distances, vertically or laterally, unless it is under considerable pressure or there are open channels and pervious material such as sand and peat for it to move through.

PHYSICAL LAWS NEED TO BE UNDERSTOOD

The knowledge of a few simple physical laws is sufficient to understand the behaviour of soil moisture. We are concerned only with two forces, gravity and capillary attraction; the water controlled by these two forces is called, respectively, gravitational or free water and capillary water. The free water moves in the soil through openings or cracks and through the pore spaces. The only resistance to its flow is the resistance of the soil particles, hence it moves rapidly in coarse soils or open and porous soils where openings and pore space between soil particles are present. This is the water that fills pore spaces in soils to the exclusion of air and is injurious to plant growth. Free water remains in the soil to the highest level permitted by natural and artificial drainage.

Capillary moisture clings to the soil particles by surface tension. It remains surrounding the particles as free water passes downwards in the soil after a rain. Before plants draw upon it and evaporation removes it from the surface, the soil contains the maximum amount of capillary water. This is the point where the capillary attraction equals the gravitational pull. It is well at this point to explain that capillary water cannot be removed by drainage. When the soil contains the maximum amount of capillary water the moisture films surrounding the soil particles are at their thickest and a portion of the pore spaces between the particles becomes filled with water. Capillary water is the main supply of moisture upon which the roots of plants draw.

Capillary movement may take place in any direction. It occurs most easily downward when it is working with gravity instead of against it. As the capillary moisture is removed from the surface soil by plant roots and evaporation, the capillary moisture seeks an equilibrium and it moves from wetter areas to drier areas. In other words, as the thickness of the moisture film is reduced on one soil particle, part of the moisture on the next particle with a thicker film moves to the thinner film by surface or skin tension till the film on both particles is in equilibrium or balance. This continues through the soil particles and creates a continual draw of capillary water from wetter to drier areas.

The films of capillary water are naturally thicker near the free water table. And it is this fact that leads many to believe that lowering the water table is injurious. Actually the contrary is true since the roots of our farm crops cannot function without the absorbed oxygen in the moisture. Where there is no free movement of moisture the oxygen utilized by the roots is not replaced and root growth is restricted. A new supply of oxygen is brought to the roots as moisture enters and passes through the soil. Also oxygen in the atmosphere is sucked into the soil as the free water is drawn away by drainage and this air conditions or ventilates the pore space

not occupied by capillary moisture. Therefore, the water table must be low enough to allow sufficient root growth to support the plant and deep extensive root growth should be encouraged by holding the top of the water table below the range of feeding roots.

Capillary Water Aids Crop Production

The free water, however, does provide a supply of capillary moisture since it can be drawn upon by capillary pull towards the drier soil above. Here again some are of the opinion that through this means moisture is supplied to plants at extreme distances from the free water supply. Actually the moisture drawn by capillarity from the water table is limited to a comparatively narrow range. Capillary water rises quickly in coarse grained soils such as sands, and rises more slowly but to greater heights in fine soils such as silts and clays. Under certain conditions capillary water may rise upwards from the water table in coarse sands as much as 10 inches in one day, but after that height is reached its movement is much slower and in 14 days it can rise only another 2 inches before reaching its limit of about one foot. In fine grained sandy loams it may rise a foot in a day and reach a limit of about 5 feet in 14 days. In silt and clay soils the upper limit of the rise of moisture from the free water table may be as high as 9 feet.

We must realize at the same time, however, that the soil directly above the water table will contain the most capillary water. As the surface of the soil is approached the amount of capillary water will become less and less because the rate of capillary movement and capillary lift decreases as the distance above the water table decreases. Therefore, from study of various data it appears that the capillary water supplied from the free water table contributes an important part of the agricultural crop needs only when the bulk of the roots is within a few feet of the free water table—within 1 to 2 feet in sandy soils and 2 to 3 feet in silt and clay loams.

It can be seen, therefore, that capillary water is at optimum effect in plant growth where a supply of free water is retained below but close to the area of unrestricted root growth. Consequently where capillary water is most effective

Figure 3.—The improvement of soil structure and organic content, along with vegetative and mechanical measures, is the best insurance that the upland farmer has in providing an adequate moisture supply for his crops.

so also is free water most frequently a problem. Too much water kills plants quicker than too little and farmers, therefore, have to depress a high level of free water to a point where the necessary amount of aeration is present at all times. So when one argues the crop production value of a capillary water supply from the free water table below, he is usually arguing about an area that needs drainage at certain times. It follows that when one is thinking of an area that does not need drainage, such an area must be one where the only capillary water available is the result of water absorbed in the surface and hence is not affected by drainage installations on lower land. This is the reason that porosity and open soil structure to allow water to be absorbed in the soil are so important in moisture supply.

RELATING FACTS TO LOCAL CONDITIONS

Let us apply some of these facts to four conditions commonly found in these controversies:

1. In this condition we have a level area of sandy or peatty soil. The soil is porous and water is readily absorbed in the soil. If the water that falls upon such an area is impounded by a more or less tight subsoil, the free water will remain at varying depths and if drained from one spot, will tend to seek a level. In such cases the water will be lowest during dry periods near the drainage channel into which it moved by gravity and there will be a ground water curve away from the channel until a point is reached where the free water is scarcely affected.

There are variations of this condition such as are found in the Newton sands in northwestern Indiana. Here we occasionally find a muck bed or area of fertile maumee sandy loam drained for crop production. At some places the poorer sand arises gradually from these depressions and before the muck or maumee soil was drained, the water table was held fairly close to the surface in the surrounding poor sandy areas. Investigations showed that capillary water rose to approximately 14 inches in the sandy soil from the free water and with this underground supply of water some cropping was possible. At more than 14 inches above the free water table, however, the supply of capillary water from the water table ceased. There undoubtedly was a case for concern here by the owners of the fringe, but to those higher than this the drainage of the bottoms had less and less affect as the elevation increased.

Figure 2.—This upland orchard is not dependent on moisture from the lowland—drained or not drained.

2. In this condition we have a sandy soil cropland elevated at least several feet above the bottom land so that the drainage of the bottom land ditch is not needed to drain the higher land. Here the higher land will not be affected by the ditch insofar as crop production is concerned, because the free water on the higher land will be drawn by gravity to the lower area whether there is a ditch there or not. To think otherwise would be to argue that a wave of water will not level or settle down to the level of the surrounding water.

3. In this condition we have level silty or clay land drained by tile or open ditch. The water may be impounded as in Example No. 1, or the soil may be so tight that the water does not drain away quickly enough. Because free water moves with difficulty to lower levels in tight silty or clay soils and there is practically no lateral movement, the removal of free water from the ditch will have far less affect on areas away from the ditch than in Example No. 1 (sand land). That is why tile and open laterals are run at intervals through the field to convey water to the ditch or main tile outlet.

(*Continued on page* 102)

Soil Conservation—Nation's Foremost Need in India

M. K. SHIROLE

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INDIA, as in the past, even today is primarily an agricultural country. Seventy percent of her teeming population of 400,000,000 people, comprising one-fifth of the world's population, still make their living directly through agriculture. The remaining thirty percent have to depend, directly or indirectly, on the farm land for their food. Agriculture has to depend on the soil for the successful growing of crops. Soil in India has been under the plow for at least 4,000 years.

By whatever standard and from whatever angle we attempt to appraise agricultural conditions in India, we find that, compared to condittions existing in Europe and America, India is still in the middle ages. There may be occasional bright patches here and there (India can certainly boast of a few model farms and a few up-to-date agricultural research stations and institutions). But, speaking generally, agriculture is still pursued in the old primitive way because the farmer is poor, undernourished and has become lazy and fatalistic because agriculture, as carried on at present, does not pay.

Men in their pursuit to grow food and fiber for clothing have constantly and continuously stirred and disturbed the soil in the past, and they are doing the same thing today, with little or no care. This indiscriminate use of land for ages in India has resulted in the deterioration and infertility of the soil. It is believed that the lowest stage is now reached. Apart from deterioration and infertility of the soil, it is the total loss of soil itself and the consequent decrease of land for cultivation that is alarming.

In the attempt to grow crops, the upper layer of the soil which is usually alive, is loosened and rendered friable by tillage operations. The land is prepared and made ready for planting the seed. Then comes the rain. Sometimes it comes slowly; at other times it pours in torrents; the water no sooner reaches the land than it begins to run down the slopes, taking along with it huge amounts of soil in its finest form.

The land in India having been subjected to the plow for ages and cultivated indiscriminately, has resulted in a topography that is rough, rugged, and undulating. Besides, there are many hills and mountains. Long time, indiscriminate wear and tear of the soils have rendered them generally very shallow in depth—at times exposing the parent material. It is no surprise to note the absence of the so-called A and B. horizon in many tracts.

The climate ranges from being extremely hot in the southwest to the cooler elevations of the mountains in the north, the whole being tropical in general character. Mt. Everest of the Himalaya Mountains is the highest peak in the world, measuring 29,141 feet. This peak lies northeast of the border of India and is covered with snow all the year round. On the other hand, the hottest part of India lies in her Sind Province, where the temperature reaches about 122° F.

Rainfall Ranges from 3 to 425 Inches

India gets her rains in two short seasons, each coming from exactly the opposite directions. The first monsoon clouds burst early in June, lasting until about the end of August, while the second season begins late in September and lasts until the middle of December. The first rains come from a southwesterly direction while the second come from a northeasterly direction. The

first monsoon is known for its greater number of rainy days and better distribution, by its characteristic drizzling showers, whereas the second monsoon—generally called anti-monsoon—is known for its brisk and intense downpour and fewer number of rainy days. Since the directions of the sources of these rains lie at extreme opposites to each other, the parts of the country benefited by the first are not benefited by the other, and vice versa, while a small belt of land lying in the middle, known as the transitory tract, is generally benefited by both. The range of annual precipitation is also very great. It begins with a minimum of about 3 inches at Leh and 4 to 6 inches in the Province of Sind to 425 inches at Cherapunji—a peak of the Himalayas. As a whole, the rains are very uncertain and irregular.

FAMINE AND SCARCITY ARE PROBLEMS

Uncertainty, irregularity, and the bad distribution of rain often results in crop failures, thus causing scarcity or famine. This is now an annual occurrence in some parts of India. Sometimes famine and scarcity results from excess precipitation and consequent floods or inadequate rains. In the Province of Bombay, the home of the author, there are two bad years (scarcity) in every five and one famine year in every ten.

The Indian farmer is an intelligent man. Years of experience have convinced him that if land and rain water are properly cared for and are made to stay in their place, the land will yield good crops. Attempts to stabilize the rain water and soil have been made for centuries. A few leading farmers have spent a great deal of money every year on land terracing or "bunding" as it is called in India. This practice has resulted in the formation of many stable bench terraces where India grows her rice today. However, this practice is confined to areas of rainfall ranging from 40 to 150 inches per year. Thus the area is comparatively limited or negligible. The need for the conservation of soil and moisture was first recognized by the Bombay and Punjab provinces in India at the beginning of the current century. Cutting forest lands in Punjab has ruined the hill-slopes and fertile cultivated lands in the valleys below. The heavy rate of soil erosion on the hill-slopes buried the good agricultural land under the debris. It also caused big ravines an denlarged streams, thus cutting up the agricultural fields.

CONSERVATION LAW ENACTED IN 1904

The Government of Punjab passed a law known as the "Chos Act"—a chos means a stream. This Act, enacted in 1904, regulates and controls the forests, canalizes the streams, restricts the cutting of trees and limits grazing only to forest land areas.

In the Province of Bombay where perhaps the occurrence of scarcity and famine is more frequent than elsewhere in India, the Government, through its Department of Agriculture, started investigations to determine the causes of famines and the ways and means of combating them successsfully. A beginning was made about 1924 when an Experimental Research Station on a small scale was established near Poona, the official monsoon headquarters of the Government of Bombay. The results of experiments made at this research station for a period of some 20 years proved very useful and encouraging. The work was shifted to Sholapur and Bijapur in 1934. These places are in the midst of the famine zones or scarcity areas. The principal "Dry Farming Research Station" was established at Sholapur while a sub-station was set up at Bijapur. The Sholapur station was fully equipped with modern scientific apparatus.

Experiments projects were laid out and studies conducted on the following important topics:

1. Rainfall; its distribution by hour, day, month, and year.
2. Intensity of rain; useful or effective rain, etc.
3. Surface run-off; experiments on the amount of rain water and soil removed from land under different conditions such as slope, nature of surface conditions (plowed, cultivated, with and without grass cover), different crops, etc.

4. Water requirements of crops and plants.
5. Moisture content of soils at different periods of the year.
6. Study of plant growth in different periods.
7. Effect of organic matter or humus on moisture contents of the soil.
8. Disposal of rain water by surface run-off, evaporation, drainage, etc.
9. Green manuring; its effect on crops and soil.
10. Improved methods of cultivation:
    a. Plowing at different times every year, alternate years, etc.
    b. Wider sowing, spacing of rows at 9, 12, 15, and 18 inches apart.
    c. Adjusting the plant population per acre.
    d. Interculture to form mulch and remove weeds, etc.

Results of experiments. The following are the most important facts obtained:

1. Water requirements of a normal crop are equivalent to 4 to 6 inches of rain.
2. To produce one pound of dry organic matter, 400 to 500 pounds of water is used.
3. Fifty per cent of the total rainfall is lost through surface runoff alone.
4. Hardly two inches of rain water remains in the soil, available for crops. This is out of a total of 25 inches annual rainfall. The remaining 23 inches are lost by way of run-off, evaporation, etc.
5. On 1 to 25% slove of cultivated land as much as 35 tons (70 cartloads) of fine soil —including plant food—is lost per acre annually; the maximum amount recorded for a single year is as high as 115 tons (230 cartloads).
6. Application of the important methods of cultivation evolved by experimentation indicates that even in the scarcity years good crops could be produced on the available moisture and rain.

GOVERNMENT HELPS INDIVIDUAL FARMERS

Simultaneously with the establishment of the Experimental Research Station, the Government

Figure 1.—A series of dry-stone plugs across the course of a stream.

of Bombay appointed an officer in the Department of Agriculture to assist farmers individually in improving their lands. Individual farms were surveyed, plans and estimates were prepared. No charge was made for these services. The improvements were mostly in the form of terracing or "bunding" as it is called in India. To induce farmers to apply these improved and scientific methods of bunding, the Government initiated Land Improvement loans called "Tagai." These loans were on a long term basis, with a reasonably low rate of interest. The utility of land improvements by scientific bunding on the contour soon became popular both among the cultivating public and the Government.

The Government of Bombay felt that these scattered efforts on individual fields were, considering the vastness of the problem and its urgent need, only a drop in the vast ocean of necessity. With a liberal donation of some $200,000 in 1940 by a Bombay philanthropist, Sir Cusru Wadia, the Government formed a trust in the amount of $400,000 to assist and induce farmers to improve their lands on a joint cooperative scale known as "Developmental Projects." The minimum area set up for a project was 500 acres in one compact area. Assuming that the cost of land improvement would be $5.00 per acre, the farmers cooperating in the plan were given a subsidy of $1.60 per acre. About a dozen such projects were set up the first year. The Government, however, felt that something more rapid and on a larger scale was needed.

Rains failed in 1942-43 and famine swept over Bijapur District. As a result, food was rationed. For the first time in the history of Bombay—and possibly in the history of India, the Government opened bunding works all over the District as famine relief. Farmers were given work in their own villages or in nearby areas, and at the same time improving their own lands to insure a permanent protection against the occurrence of famine or scarcity. In Bijapur District alone, the number of laborers reached as high as 60,000 in a single day. The improvements thus effected during the year amounted to about 100,000 acres bunded and 25,000 acres of wasteland contour trenched for reforestation. Landowners and farmers were not charged for this work as it was considered famine relief. *The large scale bunding schemes were independent and complete watersheds. The improvements started at the top of the watershed and progressed downward.*

CONSERVATION PROGRAM IS BASED ON WATERSHEDS

The Government of Bombay at the same time passed an act to assist in the work and to speed up the program. Under this law, the Department of Agriculture was empowered to select sites and apply the act to villages or areas forming complete watersheds. At a meeting of farmers and land owners within the watershed area, the Land Improvement Scheme and the act were fully explained to the people and the advantages and utility of the scheme described. If owners of 66 per cent of the land within the watershed area selected or proposed gave their consent in writing, the scheme would begin to function. Under the provisions of the act, the dissenting minority was forced to join. But so far, no occasion has arisen to test the effectiveness of such an enforcement. Village after village is coming forward on their own accord and offering their areas.

The Government finances as well as executes the scheme for the farmers. Having obtained the consent of the farmers, the staff of the Land Improvement Department (now it is a separate Department under the Commissioner of Agriculture) prepares and executes the plans. The Government furnishes all the funds to meet the cost of execution. It is assumed from past experience that the cost of improving works will amount to a little less than $4.00 per acre. The Government treats $1.00 per acre as a grant-in-aid or subsidy to the farmer; the remaining $3.00 is treated as an interest-free loan against the land, to be recovered in twelve equal annual installments. No installment is to be made the

Figure 2.—A bund (or terrace) with borrow pits from which material is taken for construction.

first two years after completion of the scheme. In addition all advice and help given by the Land Improvement staff is paid for by the Government. Thus the actual help given by the Government comes to approximately one half the cost of the scheme. So far, an area of about 800,000 acres has been protected.

The measures adopted by the Land Improvement Department of Bombay may be roughly classified under two main headings: mechanical and agronomical. The mechanical measures are concerned with suitable treatments of the soil itself and the rain water which falls upon it. The agronomical measures are concerned with the crops, herbage, and trees which grow upon the soil, and the methods required to utilize the living products of the land for its own protection.

The mechanical measures as practiced in Bombay today can be further divided into three headings, 1 contour trenching for afforestation, 2 contour Bunding, and 3 gully plugging.

CONTOUR BUNDING IS IMPORTANT

Trenches are put along the contours on all sloping upland areas and barren wastelands. Usually these areas form the catchments of the watershed. They run in long strips, at times the entire length of the field, but usually broken every 100-foot interval by a 3-foot space. These trenches are two feet wide and one foot deep. Seeds of suitable plants and forest trees are planted or sown. These trenches are spaced from 75 to 150 feet apart. The spacing depends on the nature of the land, the rainfall conditions, etc. The results obtained from the use of this mechanical measure during the past few years were very encouraging.

Contour bunding or terracing is probably the most extensively practiced and best known mechanical measure in India's soil conservation program.

In India, contour terracing has been done to a greater extent in the Bombay Province than in any of the other regions. This work is concentrated in the scarcity areas of the Bombay Deccan where it is already proving of considerable value in curtailing recurrent crop famines and failures.

These bunds, dikes or terraces are earthen structures erected along the contour of sloping land. They run uninterrupted over the entire contour of the watershed except where they cross watercourses or streams. They are from 2½ to 3½ feet above the ground level, with a 1 to 1½ foot top width, and vary in side slopes from 1 to 1½ feet. The soil that is used to build a bund is obtained by digging "borrow pits" in

the ground parallel to the contour of the bund line on the downstream side. These "borrow pits" usually have different specifications; 20 x 20 x 1 feet in light murmad shallow soil, whereas 22 x 21 x 1 feet is necessary in the deep, black, cotton soil. The depth varies from 9 to 18 inches according to convenience and necessity. Regular sizes of the borrow pits facilitate easy calculations from the earth removal and subsequent cost accounting.

Contour bunds are constructed only on land which is already under cultivation or on land that, after improvements are effected, promises to bring it under cultivation within a reasonable period of time (ten years). The bunds are spaced 300 feet apart or at 6 foot vertical distance, whichever is less. This spacing was determined after experimentation and was designed to suit economic conditions. The main object behind the construction of these bunds is to retain all the rain water and silt and keep them in their place by spreading the flow of water and silt evenly over the entire length of the contour bund. Moisture and silt thus spread evenly results in insuring a uniform crop growth all over the bunded area.

GULLIES RESULT FROM MISUSE OF LAND

Indiscriminate land use or, rather the misuse of land in India, has resulted in an increase in the extent, size, shape, as well as the number of gullies in their enlarged and final form. Attempts to check and improve them are part of the soil conservation program. The measure to accomplish this is called a gully plug or check dam. The structures are erected either by putting up dry stone or brushwood groynes across the flow at suitable sites and frequent intervals. Stone structures are usually used to treat comparatively bigger streams, whereas wooden structures are usually used in smaller streams, preferably in fields where stone is difficult to obtain.

The agronomical methods involved are the scientific and planned utilization of crops, grasses, legumes, shrubs and trees in checking soil erosion and in building soil fertility.

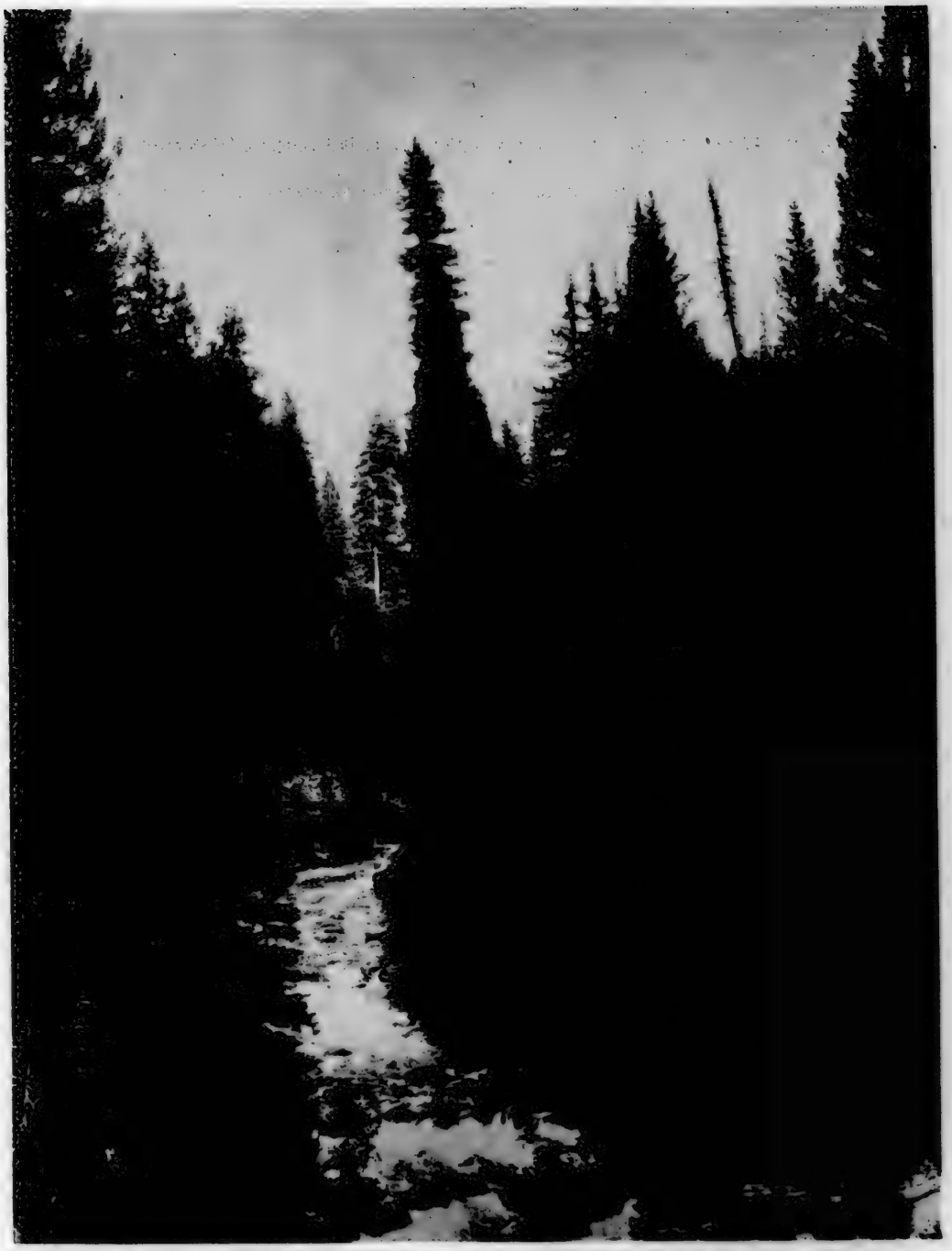
The conservation program now advocates all tillage or cultivation operations on the contour to supplement contour bunding. On the more level lands, effective contour tillage may do away with the need for contour terracing. Therefore, more attention needs to be paid to the introduction and expansion of contour tillage in India as it is an important and effective soil conservation practice which costs very little and its adoption imposes no additional financial burden on the poorest of farmers.

DRY FARMING METHODS HELP CONSERVE MOISTURE

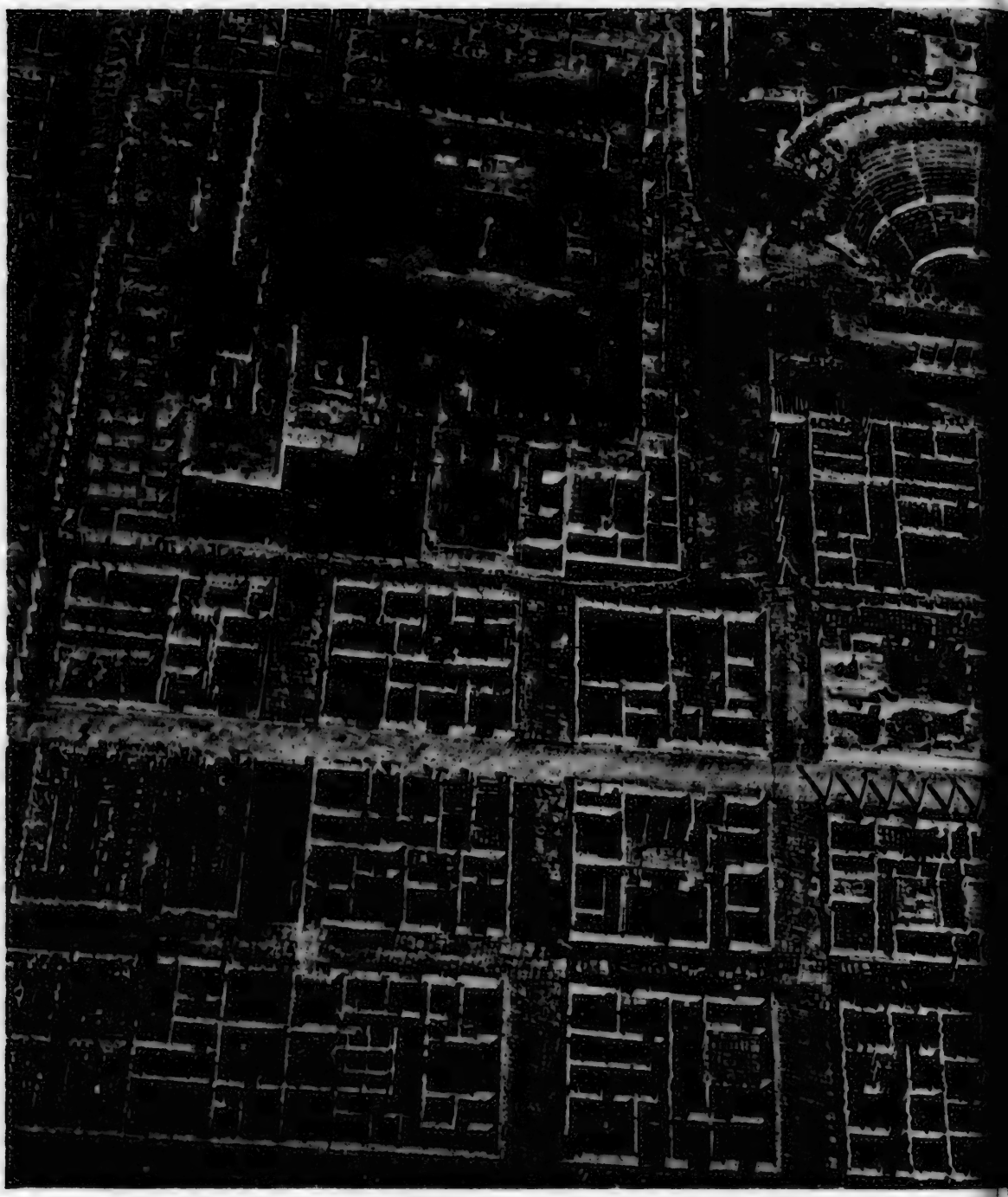
Experiments conducted on the aforementioned Research Stations for some 20 years have evolved a method of cultural practice which, if carried out on the land, insures successful growth of crops even in scarcity years. These methods are directed towards conserving moisture in the soil—which is so very essential in the scarcity areas—and adjusting plant population. The following features constitute the Bombay Dry Farming Method:

1. The ideal depth of land should be about 18 inches.
2. The areas should be divided into small plots of approximately one acre each. Each plot should be bunded (enclosed in a ridge or dike) only about 9 to 12 inches high, on all its sides—especially the lower side. The idea here is to impound all the rain water in the plot.
3. The land should be plowed once in every three years, and harrowed twice every year.
4. Farmyard manure should be applied to the land at the ratio of 5 cartloads (2½ tons) to the acre.
5. An improved type of grain sorghum seed (locally known as jowar), developed on Government farms through breeding, should be sown on the plot. This sorghum seed (jowar) should first be treated with sulphur to insure it against smut, and then planted at a rate of from 4 to 6 pounds to the acre.
6. The crop to be sown 15 to 18 inches apart

(*Continued on page* 106)



A normal stream flowing from the high mountains into the valleys of Utah. It can be preserved indefinitely by a modest but comprehensive research program to guide management of lands from where it comes. Photo by the Forest Service.



Timgad, North Africa, former glory of Rome, today is deserted and surrounded by desolate country with a sad ending—a period of prosperity, followed by one of struggle with diminishing productivity with promise of only partial restoration, or none at all, of the former productive capacity

ryside. Behind all these ruins is the stirring drama of hunger and destruction of life. It is a story
nity, caused by man-induced erosion, and finally defeat and death. The former population is gone,
apacity of the land. Photo by Horace Hines, 12th Air Force, United States Army.

An air view of Centerville Creek, Utah, showing a destructive mud-rock flow. Damage resulting from floods to this kind of agricultural, industrial, and residential property because of radically changed run-off conditions since the turn of the century, amounts to several million dollars. Photo by the Forest Service.

What Becomes of Our Rainfall?

F. R. DREIBELBIS

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THE CONSERVATIONIST of necessity is interested in the weather and particularly in the amount and distribution of rainfall. He knows, of course, that much of the rainfall may be absorbed by the soil where it can be utilized for plant growth, contribute to ground water for well supply and for replenishing springs, or remain in the soil as storage. He also knows that under certain conditions much of the rainfall may be lost as surface runoff which carries with it varying quantities of valuable topsoil.

The hydrologic installations at the Soil Conservation Service experiment station, Coshocton, Ohio, furnish basic information pertaining to agricultural hydrology. The effects of land use and erosion control practices on soil and water conservation and on floods are studied here. The function of the soil as a water-storage medium in the conservation program is of particular interest.

Findings Have Wide Application

The Coshocton station represents the North Appalachian Region to which the results in general are applicable. It is anticipated that some of the findings may have a wider application or interest.

First, let us consider, in its simplest terms, the process by which rainfall is disposed. Qualitatively, disposal factors are simple and direct in their operation. The quantitative evaluation of them is indeed complicated. Broadly speaking, rainfall reaching the soil surface is divided into two parts: infiltration into the soil, and surface runoff. What the former cannot take constitutes the latter. (A more detailed study would take into account the water intercepted by plants, and the amount left as depression storage.) Once the water is absorbed by the soil the excess is disposed of either by plants through transpiration, by evaporation, or it percolates through the soil profile to contribute to ground water or springs. The water remaining is held by the soil as storage. The weather, which includes the rainfall, sunshine, temperature, and humidity, obviously will affect one or more of those processes.

The amount of water disposed by those various means varies considerably from year to year due to meteorological changes and to the influence those changes exert on plant growth. Although they do vary, there is a certain amount of regularity in the ways water is disposed from year to year. Percolation takes place mostly in late winter and early spring; evapo-transpiration mostly during late spring and summer. Soil moisture changes also tend to have a definite trend.

Curves Show Water Storage

Note the trends of soil moisture storage for three successive years, 1943-1945, figure 1. The curves show the amount of water stored in the upper 40 inches of soil. That depth includes most, if not all, crop roots. High evapo-transpiration rates during the summer reduce the water content of the soil. In spite of frequent rains in the summer, the minimum amount of soil moisture is found either in August, September, or October, the time depending on weather conditions.

Although the soil moisture is low and storage opportunity is high in summer and early fall, this is the period of greatest rainfall intensity and of most runoff and soil loss from farm fields. Data from one of the Coshocton watersheds, figure 2, show that the period of highest runoff occurs in the summer months when soil-water storage capacity, ordinarily, is ample.

Similarly, soil loss values in particular are considerably greater in the summer months than at other times.

Although the foregoing points out that the summer months are the critical ones for runoff and erosion, it should not be concluded that there is none at other seasons. Under a wide variety of weather conditions, the winter and spring months also contribute to soil and water loss. The emphasis of the importance of soil conservation practices should be placed primarily on conditions during the growing season because then the soil-water storage capacity can be used if the proper conditions of infiltration permit. Conservation practices such as contour cultivation, strip cropping, mulch culture, and other improved land use contribute toward increasing infiltration and reducing runoff and soil losses.

FIVE TONS OF SOIL LOST

Observations on Russ Gonder's farm in June 1944 show how the soil-water storage capacity was used in one case and not in another. Two storms occurred—each of 1 inch rainfall total; each at high rates. In the top 40 inches of soil there was sufficient empty pore space to take up about *four* times the combined total rainfall of these two storms. Yet ½ inch water ran off Gonder's plowed corn field. Five tons of top soil was removed from each acre in this field. In contrast, there was no runoff or erosion from his mulched cornfield.

In one case, the plowed field offered no protection against the force of beating rain drops. There the soil surface sealed. Infiltration was very low. In the case of the mulched field, high infiltration was maintained and soil pores were used to store rain water.

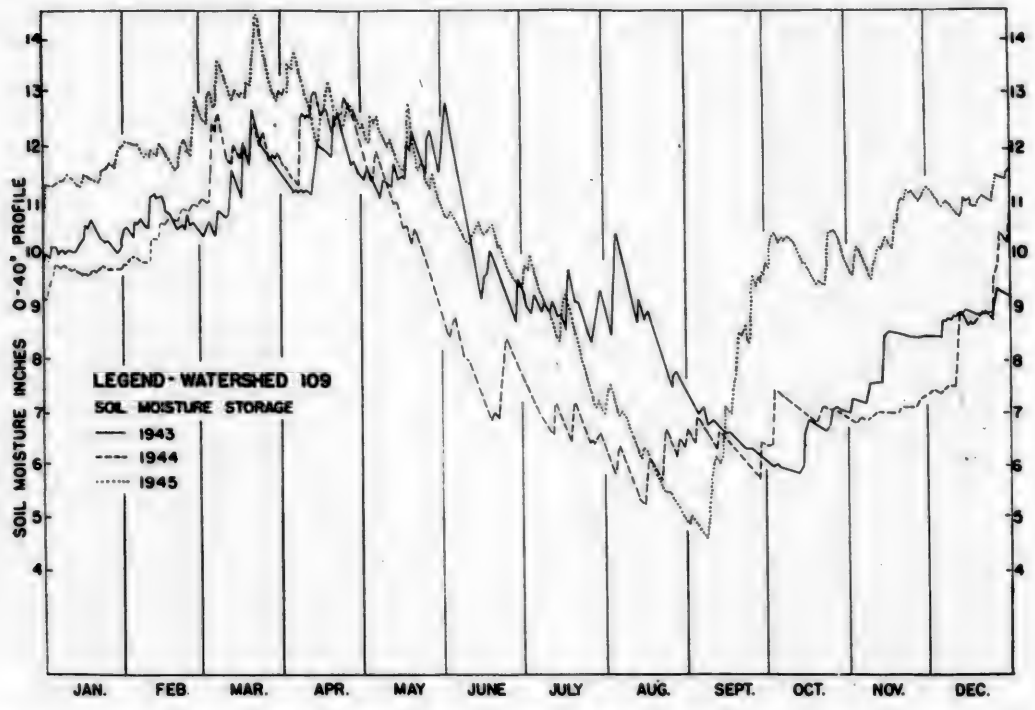

Figure 1.—Trends of soil moisture storage in the 0-40" Muskingum silt loam profile for 1943, 1944, and 1945.

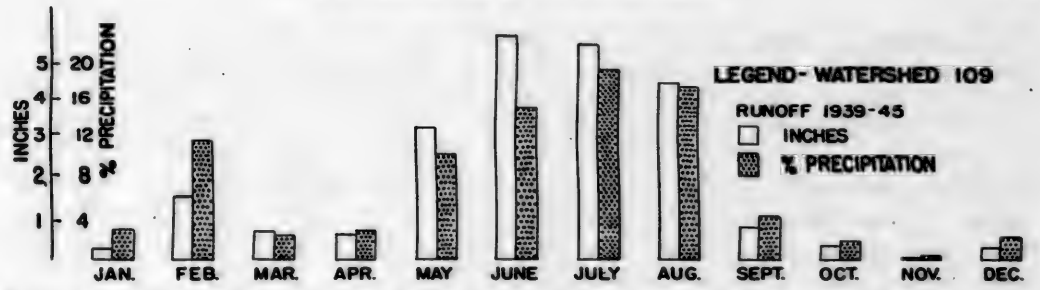

Figure 2.—Average monthly runoff from the Muskingum Silt loam watershed (4-year rotation) for 1939-1945.

More information regarding the water storage opportunities of the soil is furnished by the data in Table 1. The calculated maximum possible water storage indicates the amount of water that would be held by the soil if all the pores were filled with water. The minimum found represents the least amount held in the soil under field conditions. The difference represents the possible accretion. Those data show that the surface soil (0-7") could receive up to 3.1 and 3.2 inches of water on the two cultivated watersheds respectively, the amount depending upon the water already present in the soil. For the entire 24-inch depth the capacities are 7.8 and 8.1 inches, respectively. The data for the woodland soils are probably not as accurate because biological channels and structural voids occur. These facilitate soil-water movement and serve also as part of the soil-water reservoir. This, however, cannot be determined as accurately as in cultivated soils. The data in Table 1 emphasize the conception that the soil profile can function as a water-storage capacity medium. Data (1) for the 0-40" profile were previously given.

Evaluated on Energy Basis

Interesting as the data are on the distribution of water in various layers of the soil, it should be pointed out that more recently soil investigators have placed greater emphasis on the distribution of forces responsible for the retention and movement of water in the soil. In other words, to evaluate soil moisture on an energy basis.

Schofield (2) has introduced the idea of using the logarithm of the capillary potential, pF, to express the energy with which water is held by the soil. pF is defined as the logarithm of the height in centimeters of a liquid column that is necessary to produce the desired suction at which the remaining water is held in the soil. In Table 2 are shown the amounts of moisture held by various layers in

TABLE 1

Maximum and minimum soil moisture values and the possible accretion for various soil depths (expressed in inches water)

Soil[1] depth (inches)	Calculated maximum possible water-storage			Minimum field moisture found			Difference (possible accretion)		
	Keene silt loam (cultivated)	Muskingum silt loam (cultivated)	Muskingum loam (woodland)	Keene silt loam (cultivated)	Muskingum silt loam (cultivated)	Muskingum loam (woodland)	Keene silt loam (cultivated)	Muskingum silt loam (cultivated)	Muskingum loam (woodland)
0-7	3.8	3.7	2.5	0.7	0.5	0.3	3.1	3.2	2.2
7-14	3.5	3.4	3.1	1.1	0.8	0.6	2.4	2.6	2.5
14-24	4 4	3.5	3.5	2.1	1.2	1.0	2.3	2.3	2.5
Total	11.7	10.6	9.1	3.9	2.5	1.9	7.8	8.1	7.2

[1]Soil depths for the Muskingum loam were 1-6, 6-14, and 14-25 inches.

three soil types at various pF values. pF 1.6 which represents the approximate dividing line between capillary and noncapillary pores indicates the amount of water held at a tension of 40 centimeters. Water between this pF and saturation is held rather loosely and can move rather freely through the noncapillary pores and much more rapidly than above pF 1.6. Soil water from pF 1.6 to 4.5 is held more firmly and more force or energy is required to remove this water as the pF values increase. At pF 4.5, the hygroscopic coefficient, the water is so firmly held that plant roots can not extract it from the soil rapidly enough and plants wilt. Water held between pF 1.6 and 4.5 is largely capillary water and moves rather slowly but is available to plants up to about pF 4.2 when permanent wilting generally takes place.

Because pF values are logarithmic expressions, it should be emphasized that a small change in pF values in the dry range corresponds to a considerable change in tension while a similar change in pF values in the wet range corresponds to only a small change in tension. For example, the tensions at pF 4.2 and at pF 4.5 amount to 30,103 and 69,897 centimeters respectively, while at pF 1.6 and pF 2.0 they amount to 40 and 100 centimeters, respectively.

The data in Table 2 indicate that the Keene silt loam can retain more water at the same pF than the Muskingum silt loam and the latter more in turn than the Muskingum loam. This is particularly evident in the subsoil where the profile characteristics show a greater contrast than in the surface soil. The subsoil (20-40" depth) of the Keene silt loam is a heavy silty clay while in the Muskingum soils at the same depth the texture is very light, ranging from a loam on watershed 109 to sandy loam in watershed 131.

TABLE 2
Soil moisture content at various pF values
(expressed in percent by volume)

Soil type	Depth (inches)	Soil moisture at pF of— (Saturation)	1.6 (40 cm. tension)	2.7 (moisture equivalent)	4.5 (hygroscopic moisture)
Keene silt loam	0-7	53.2	39.3	30.1	5.0
	7-14	49.4	41.9	36.1	8.7
	20-40	48.1	41.0	38.4	14.5
Muskingum silt loam	0-7	43.2	39.3	30.1	5.0
	7-14	48.5	39.0	30.2	8.2
	20-40	37.5	29.9	23.4	5.7
Muskingum loam	1-6	49.6	31.5	21.9	4.8
	6-14	38.1	28.7	22.0	2.9
	20-40	40.7	32.1	23.1	3.7

TWO EXTREME YEARS COMPARED

A monthly summary of water disposal as determined by weighing monolith lysimeters appears in Table 3. The years 1944 and 1945 represent two extremes in precipitation, the former being below normal and the latter above. It should be pointed out that precipitation is not the only source of accretion. Records at this station have shown that from 4 to 7 inches of water per year are obtained by condensation. This water is largely disposed of by evaporation.

Evapo-transpiration constitutes, by far, the greatest percentage of water disposed for the year. These amounts are very low in winter when some evaporation takes place. In spring as temperatures rise, rates of evapo-transpiration increase. The disposal by transpiration alone generally exceeds that of evaporation during May, June, July and August when total evapo-transpiration usually exceeds 4 inches per month. The average daily disposal by evapo-transpiration for these months is generally in the neighborhood of .15 inch per day. (For daily values see Harrold and Dreibelbis) (3). Beginning in September, rates of evapo-transpiration decrease owing both to lower transpiration and lower evaporation rates. This is largely due to shorter days, lower temperatures and soil moisture conditions. The above values of evapo-transpiration emphasize the importance of conservation practices for soil moisture storage, both for crop production and for runoff and erosion control.

TABLE 3

A monthly summary of the accretion and disposal of water on the Muskingum silt loam as determined by weighing Monolith lysimeters. (Expressed in incres water)

Month	Total accretion				Depletion					
	Precipitation plus condensation-absorption		Runoff		Evapo-transpiration		Percolation		Total	
	1944	1945	1944	1945	1944	1945	1944	1945	1944	1945
January	2.23	3.06	0	0.08	1.52	1.50[1]	0	0.26	1.52	1.84
February	2.63	4.41	.02	.02	1.28	1.50[1]	.01	2.22	1.31	3.74
March	7.37	9.83	.02	.19	2.01	2.80	3.46	7.74	5.49	10.73
April	4.62	4.88	.01	.05	2.28	3.48	3.22	1.82	5.51	5.35
May	2.60	5.98	0	.20	4.53	4.85	.50	1.83	5.03	6.88
June	3.92	4.91	.05	1.09	4.52	3.97	.10	.34	4.67	5.40
July	2.92	3.05	.06	.08	4.25	4.73	.02	.13	4.33	4.94
August	4.91	1.42	.16	.05	4.38	4.16	0	.04	4.54	4.25
September	2.50	11.93	.04	3.74	3.16	3.40	0	.01	3.20	7.15
October	2.66	3.65	.01	.39	2.26	3.20	0	.25	2.27	3.84
November	2.29	4.84	0	.05	1.69	2.32	0	.68	1.69	3.05
December	4.99[1]	3.56[1]	.06	.40	1.00[1]	1.00[1]	.02	.93	1.08	2.33
Total	43.64	61.52	.43	6.34	32.88	36.91	7.33	16.25	40.64	59.50

[1]Estimate. Records show exaggerated values due to drifting of snow.

NEED WATER DISPOSAL CONTROL

A study of the data in Table 3 indicates the progressive farmer should attempt to control water disposal. First, he should be concerned with reducing runoff. Once water is lost by surface runoff it is gone as far as use to the farmer is concerned, unless utilized in farm ponds. Varying amounts of water may be conserved through conservation farming such as contour cultivation, strip cropping, and other proper land use practices. The problem of reducing and controlling runoff is one of the principal objectives of soil conservation since runoff is so closely related to soil erosion. Once runoff is conserved it may increase evapo-transpiration, percolation, storage or all of them. Percolation may be both beneficial or detrimental. In general, percolation, when not excessive, is beneficial because it aerates the soil and replenishes springs and raises the water level both of which are useful in supplying water for stock and farm purposes. Percolation when excessive may be detrimental through loss of plant nutrients by this means. Generally, this loss has been exaggerated. The goal is to reduce runoff and to minimize percolation by promoting luxurious vegetative growth through judicious use of manure and fertilizers, thereby removing more water by transpiration.

MANY FACTORS AFFECT VALUES

The percolation values in Table 3 afford a good indication of water disposal through ground water. In 1944, a year of low rainfall, 7.33 inches contributed to ground water. In 1945, a year of high precipitation, the amount was 16.25 inches. In general, most values should be between those extremes for that soil type. Various factors will affect percolation values.

High rainfall intensity tends to increase runoff which in turn will decrease percolation. Land use likewise will tend to affect it. Crops such as corn or wheat which afford less protection to the soil than meadow, pasture, or woodland areas, tend to have greater runoff and therefore less percolation than the latter. Soil type also has a great influence because water will percolate much more readily through some soils than others. The texture and structure of the soil influence percolation appreciably. Percolation is more rapid through light soils than through heavy ones except where percolation proceeds along the cracks as sometimes happens when soils are dry enough to cause shrinking and the formation of cracks. Fertility affects the amount and rate of percolation only indirectly through the growth of plants. In gen-

(*Continued on page* 108)

MOISTURE AND DRAINAGE

(*Continued from page 86*)

4. In this case we are considering elevations of silty or clay soils above low undrained areas. If water moves even with difficulty through this soil under the influence of gravity, and only a few feet at best by capillarity, then what reason is there to expect water to move laterally and vertically from the low areas to feed the crops on the higher surrounding areas. The water supply of this high land is absolutely dependent upon water that is absorbed by the surface and is not affected by the drainage of the low land.

FREE WATER DOES NOT MOVE AGAINST GRAVITY

The free water moves by gravity from higher to lower areas as best it can through the soil. If the higher land does not need the tile or ditch of the bottom land for drainage, then it likewise is unaffected by the removal of free water from the bottom land. No free water moves against gravity and movement of capillary water from the low land to the high land is impossible.

Let us look around us and see some proofs we may observe readily. Here is a farm pond—if the pond holds water against the pull of gravity, then it is not even supplying moisture to the crops growing on lower land, let alone those at a higher elevation. During a drought dig a hole near the pond but 2 or 3 feet above the pond water level and test the theory that the water in low areas supplies the demands of crops on higher. You will find the soil just as dry a few feet elevation above the pond as 100 ft. above it. Also observe the vegetation in a low undrained area or around the border of a pond or swamp. You will note that at a foot or two elevation above the level of the free water, the vegetation changes and you will find the same kind of vegetation at 100 ft. elevation as at 2 or 3 feet. Here is the best answer to this whole problem. The swamp or pond border vegetation is maintained for just as far above the swamp or pond as the free water affects it. At that point, the vegetation changes to the well-drained type of vegetation that continues the same up the hill as long as soil conditions are similar.

If a farmer wonders whether drainage of some low land will affect his higher field, let him check if the low land or swamp vegetation continues up to and into his field. If it does, he needs drainage. If it does not, it doesn't make any difference whether the low land is drained or not so far as his upland field is concerned because it is dependent for water supply only upon the rain that falls on it.

Usually the bottom land farmer has a much better case against the upland farmer whose free water and erosion debris floods his land and clogs his ditches. In most cases the answer to the upland farmer's problem is to keep his water at home by good water-conserving practices.

If we are hearing more and more about droughty conditions on upland areas, let us face the facts and admit that the cure to a great extent lies in the hands of the upland farmer. These same droughty uplands once supported a canopy of luxuriant forest growth. There was overhead protection from sun and beating rain, there was a deep litter of leaves and decayed organic matter to protect the soil, there was a deep layer of porous, loamy, top soil that allowed about 25% more water to infiltrate into it than nowadays. And, due to its spongy nature, the water that infiltrated the soil was held longer for plant use.

The upland farmer has cleared his land and often has allowed the good top soil to wash away, leaving a compacted sub-soil. Most of the rainfall runs off, leaving little in the soil. Upland farmers should study how to improve the structure and porosity of their soils, increase the organic content, install erosion-control and moisture-conserving practices, and in this way solve their soil moisture problems. Such activities would be more constructive than fighting for water that is now lost to them, while blaming the results of their neglect on the man lower down. In many cases the low land farmer is contending not only with the natural wet bottomland conditions, but is being forced to deal with more water than nature intended.

Effects of Soil Conservation on Reservoir Sedimentation in the Southeast

GUNNAR M. BRUNE

MR. BRUNE is Regional Sedimentation Specialist for the Soil Conservation Service with Headquarters at Milwaukee, Wisconsin. The content of this article, however, concerns sedimentation studies in the southeast where Mr. Brune was originally stationed.

IN THE SOUTHEASTERN States there is a very pressing need for information as to just how much a soil conservation program will reduce sedimentation, particularly reservoir sedimentation. A large amount of data has been published on soil losses in this region from experimental plots under different types of cover and different farming practices. However, as has been pointed out before by Brown (1), soil losses as measured from experimental plots may differ widely from losses on complete drainage areas, as a result of deposition on slopes and floodplains and erosion of channels.

What is needed, therefore, is a study of rates of silting in given reservoirs before, during, and after treatment of the drainage areas with soil conserving measures. In the Southeast there are many reservoirs in whose drainage areas such measures have been partially established. On only three of these, however, High Point, North Carolina, Newnan, Georgia, and Roxboro, North Carolina, have sedimentation surveys been made more than once, so that the reduction in rates of silting as a result of soil conserving measures may be estimated. This paper reports a study of the apparent reduction in rates of silting that has taken place in these three reservoirs, in an attempt to determine the magnitude of the reduction that may be expected from a well planned soil conservation watershed treatment program.

Description of Measures Applied

Newnan, Georgia—At the time the Newnan Reservoir was constructed for municipal water supply in 1924, its 1.39-square mile drainage area was eroding at a serious rate. Only about 35 percent of it was covered by second-growth scrubby woodland. Almost immediately, in 1925, the city began purchasing the land and planting it to pine trees. Firebreaks were cleared to prevent the destruction of this woodland by fire. A large number of wire and brush check dams were built to help stabilize gullies and washes until the trees could take root. By 1945 about 83 percent of the watershed was in forest or new plantings, and the city was continuing its land purchase and retirement program (2).

High Point, North Carolina—At this municipal reservoir, constructed in 1928, the problem was entirely different. Here was a drainage area of 62.3 square miles of productive farm land. Obviously, the cost of purchasing this whole drainage area and retiring it to forest would be prohibitive. Since a wholesale change of land use was not possible here, the erosion and the sediment load carried into the reservoir had to be reduced by some other method. This method was conservation farming.

In 1934, the drainage area was selected as an erosion-control demonstration project of the Soil Conservation Service. Between 1934 and 1938, when the project was placed on a maintenance basis, the following practices were put into effect: Approved rotations were applied on 11.4 percent of the area, strip cropping on 6.5 percent, terracing on 7.3 percent, pasture improvement on 1.1 percent, tree planting on 0.9 percent, meadow outlets and disposal areas on 0.4 percent and kudzu and sericea plantings on 0.1 percent. Conservation farming practices of one kind or another were applied on 20 percent of the drainage area.

The following table shows that no appreciа-

ble changes in land use were made during this program:

	1934 (percent)	1938 (percent)
Cultivated	35.7	34.1
Permanent hay	0.4	0.6
Pasture	6.6	9.9
Wooded pasture	7.7	7.7
Woodland	42.8	43.2
Wildlife	0.1	0.4
Idle	4.3	1.6
Miscellaneous	2.4	2.5
Total	100.0	100.0

Roxboro, North Carolina — This reservoir, constructed in 1925, has a history similar to that of High Point. Although the drainage area is not so large, it is large enough (7.29 square miles) to make purchase and reforestation of the area by the city impracticable. Here again, therefore, the effort has been to reduce the sedimentation of the reservoir by conservation farming.

In March 1939, the farmers of this area, realizing the benefits to themselves of conservation practices, not to mention the benefits to the reservoir below, banded together to form the Dan River Soil Conservation District. Between that time and November 1946, the following practices were put on the land: Approved rotations were applied on 13.9 percent of the area, terracing on 16.2 percent, contour farming on 12.8 percent, pasture improvements on 1.0 percent, tree planting on 0.2 percent, woodland improvements on 0.4 percent, water disposal areas on 0.5 percent, and plantings of kudzu, sericea, and other perennials on 1.0 percent. Conservation farming practices of one kind or another were applied on 20 percent of the drainage area.

Here also, as shown in the following table, no appreciable changes in land use were made:

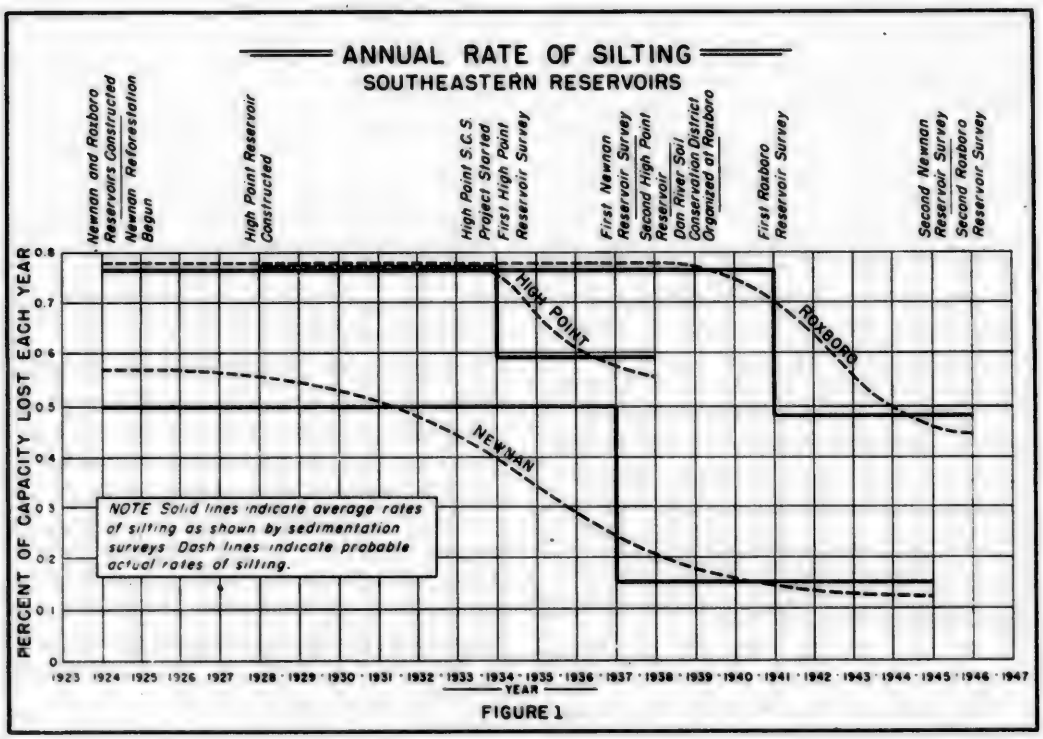
ANNUAL RATE OF SILTING
SOUTHEASTERN RESERVOIRS
Newnan and Roxboro Reservoirs Constructed
Newnan Reforestation Begun
High Point Reservoir Constructed
High Point S.C.S. Project Started
First High Point Reservoir Survey
First Newnan Reservoir Survey
Second High Point Reservoir
Dan River Soil Conservation District Organized at Roxboro
First Roxboro Reservoir Survey
Second Newnan Reservoir Survey
Second Roxboro Reservoir Survey
HIGH POINT
ROXBORO
NEWNAN
NOTE Solid lines indicate average rates of silting as shown by sedimentation surveys Dash lines indicate probable actual rates of silting.
PERCENT OF CAPACITY LOST EACH YEAR
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943 1944 1945 1946 1947
YEAR

FIGURE 1

	1939 (percent)	1946 (percent)
Cultivated	35.9	37.3
Permanent hay	0.2	0.6
Pasture	5.1	5.7
Wooded pasture	2.9	3.2
Woodland	49.7	48.2
Idle	3.6	2.4
Miscellaneous	2.6	2.6
Total	100.0	100.0

EFFECTS

Newnan—Two reconnaissance sedimentation surveys have been made by the Soil Conservation Service, one in 1937 and one in 1945. These surveys indicate that during the period 1924 to 1937 the average annual rate of storage capacity loss from silting was 0.50 percent, whereas, during the second period, 1937 to 1945, the average annual rate was only 0.15 percent. This is shown graphically in figure 1. However, we are not so much interested in average annual rates as we are in the trend of silting year by year. In other words, since the reforestation of the Newnan watershed was a continuing process from 1925 to 1945, one would expect the rate of silting to be higher than the average at the beginning and lower at the end of each of the two periods covered by the reservoir surveys. The probable trend in the rate of silting is also shown in figure 1.

Based on this interpretation, there has been a reduction in the annual rate of silting of Newnan Reservoir from 1925 to 1945 of about 78 percent. The average annual runoff from the drainage area is estimated to have been approximately 10 percent lower after 1937 than before, but the number of intense storms annually was about the same in each period. Under normal storm and runoff conditions, it seems probable that the reduction in the annual rate of silting would have been about 70 percent as a result of the improved land use program.

High Point—The Soil Conservation Service made two detailed sedimentation surveys of this reservoir, one in 1934 and one in 1938. In this case the surveys showed that the average annual rate of capacity loss from silting dropped from 0.77 percent during the first period to 0.59 percent during the second.

As the High Point trend curve in figure 1 shows, there was a reduction in the probable actual rate of silting of this reservoir from 1934 to 1938 of about 27 percent. Hydrologic records reveal that there was at least an equal number of intense storms and about 20 percent higher total runoff annually in this drainage area after 1934 than before. Under normal storm and runoff conditions, it is to be expected that the reduction in the annual rate of silting would have been greater, probably about 35 percent, as a result of the conservation farming practices applied in the drainage area.

Roxboro—The Soil Conservation Service made a reconnaissance survey of this reservoir in 1941 and a detailed survey in 1946. In this case the average annual rate of silting during the first period (1924-1941) was estimated to be 0.77 percent. This figure is lower than that previously published by Brown (2) because the 1946 survey permitted a more accurate recomputation of the original capacity of the reservoir. During the second period (1941-1946), the average annual rate of silting was found to be lower still, 0.48 percent.

As shown by the trend curve in figure 1, the probable actual rate of silting was reduced by about 43 percent between 1939 and 1946. Hydrologic study shows that the annual runoff was about 12 percent lower and that the number of intense storms annually was considerably lower after 1941 than before. Under normal storm and runoff conditions, the reduction in the annual rate of silting would have been less, probably around 35 percent, or the same as at High Point.

PROBABLE EFFECTS OF A COMPLETE CONSERVATION PROGRAM

The data presented here indicate that at both High Point and Roxboro it was possible to reduce the rate of silting by about 35 percent, by applying simple conservation farming practices on 20 percent of the watershed land. If conservation farming practices without any large land

(*Continued on page* 108)

CONSERVATION IN INDIA

(*Continued from page 92*)

in rows.

7. Four intercultures with blade-hoes, to be given during the crop growing period. This intercultivation removes the weed growth and forms a loose layer on the surface. This is better known as mulch.

Crop rotations are fairly common in India and they are being further improved by the Department of Agriculture. Deep rooted crops are usually rotated with shallow rooted crops and often by legumes and oil seeds which improve the soil fertility.

SOIL CONSERVATION INCREASES YIELDS

Application of soil and water conservation practices to the land on a field scale have shown a substantial increase in crop returns.

1. Increase in crop yield due to contour bunding alone 25%
2. Increase in crop yields due to contour bunding supplemented by dry farming methods of cultivation 55%

These increased returns are both on an average, whereas the maximum returns obtained were over 300%. The average yield of jowar per acre is around 500 pounds. The maximum yield obtained through the above methods of improvement gave around 1,550 pounds per acre. These figures are only for grains. Similar increases in fodder were also obtained.

So far as the Bombay Province is concerned, 95% of her area is primarily dependent on the precipitation of the monsoon which is sporadic in its distribution. Hardly 5% of Bombay's agriculture is carried on by irrigation—hence the need for soil conservation and judicious use of land according to its need and capability. What holds good in Bombay will hold good in India as well.

INDIA ORGANIZING NEW CONSERVATION PROGRAM

Soil erosion admittedly is accepted as a national evil in India. With the advice of two American experts, the Government of India is now organizing a Board of Soil Conservation and Land Utilization in the Department of Agriculture. The country for the present will be divided into three regions: 1 Northwest, 2 Northeastern, and 3 the Peninsular Area. The Board will have an administrator—a high revenue officer—with one agronomist, one soil scientist, one irrigation and drainage engineer, and one forester. The majority of these experts will probably be recruited from the United States.

Each region will have the same number of the several experts. They will be responsible for laying out experimental soil conservation projects in a few places in each region and also get them under way. The training of the staff required to expand the work as well as the training of the local staff under them will also be a duty of these experts. The Board will be responsible for laying down the policy with regard to soil conservation and land utilization work throughout the country. It is vitally important that the Board be made up of real experts, as upon them will depend the whole future of this work.

The Regional units will be responsible for research and experimental work. They will be responsible for the training of a Provincial Staff and for rendering advice to the Province in the formulation and execution of Provincial Projects. The staff for each regional unit will be recruited from among experienced men in soil conservation work in India. They will be sent to the United States for training for approximately one year and on return will take up the work of training the staff under them at the regional units and the staff for Provinces as stated above. The plan at the present is based on a period of five years. Actual work on the land will commence at the end of the first year when the staff in charge of the region returns from their training in the United States.

Bombay Province is already ahead in this work as she has already sent three of her experienced and senior officers—the author of this article being one of them—to the United States for training with the Soil Conservation Service.

These men will build and make the land secure in India. There can be no greater service toward one's country than saving the soil!

From the President

ONE OF THE HEALTHIEST factors about the Soil Conservation Society of America is its acknowledgment that the Science of Soil Conservation is comparatively new.

It is impossible to enumerate the many possibilities in the science of soil and water conservation needing further intensive study. Here are a few: flood retardation, domestic water supply, wildlife and land use, siltation, sustained productivity of the land, and the relationship of soil and human nutrition. These are a few of the fields that need a much wider latitude of coordinated investigation and research.

Briefly, I want to mentiton a field that is particularly pertinent—one which has been talked about and about which little is known. I refer to the relationship of soil and human nutrition. We have some facts that were obtained from a few people who made a study of this subject. Dr. Albrecht and others in the field of soils and Dr. Jonathan Forman along with several physicians in the field of medicine have helped throw considerable light on this vital subject by their recent work. Nevertheless, this field is wide open for more investigation and research.

How can we know that the foods we buy come from soils containing the nutrients necessary to perpetuate healthy bodies? Do we know enough about the necessary soil and water conservation measures that will help assure the production of such foods? Just what is the effect of so-called "poor soil" on the food grown from it and how does it affect the welfare of the body?

Factual and reliable answers to these questions and many others relative to the subject of soil and nutrition will be found only after an adequate program of research has been developed. There are many avenues of investigation. The experiment stations of colleges, extension services, industry, the medical profession, the research facilities of the U. S. Department of Agriculture and the Soil Conservation Service, and others can all make contributions.

Several groups are looking to the advancement of the Science for help and guidance in this all important matter. We already have an expression of keen interest from soil conservation districts; from local, state and national levels. Industry, professional and scientific organizations, and professional leaders engaged in research and education are aware of the need of study and investigations. In fact, the general public is already "straining at the traces" for more information on human nutrition as it relates to the soil where food is produced.

Here, I am convinced, is a real opportunity for the Society to help coordinate the efforts from all sources to find ways of bringing about a more intensified study. Many agencies interested in this field have some facts and general information which may help shed more light on the entire area of study. It seems to me that the Society can point the way for consolidating this information so that it will be useful for further work on the problem as a whole. Soil conservationists and other professional and scientific groups need to secure the necessary facts to meet this challenge. Our Society can and should assume a major role in exemplifying the leadership essential to bring this about. How can this job best be done? What are your suggestions?

H. H. Bennett

RESERVOIR SEDIMENTATION

(*Continued from page* 105)

use changes were applied on 40 percent of the land, properly selected to include the principal sediment sources, a reduction of 65 percent in the rate of silting of these reservoirs might be reasonably expected.

In the case of Newnan Reservoir, the rate of silting was reduced by about 70 percent through land use changes involving an increase in the percentage of forest cover in the watershed from 35 to 83 percent, supplemented by forest management and erosion control practices.

Now, let us assume that in a given reservoir watershed in the Southern Piedmont we apply conservation farming practices on that 40 percent of the land where they are most effective, and also retire other sizable blocks of badly eroded land to permanent pasture or woods. In addition to these measures, let us supplement our program with an integrated system of water and sediment control and disposal measures, such as sedimentation basins, detention-type ponds, permanent gully-control structures, highway erosion-control plantings, and stream-bank protection measures. By following such a program we may be reasonably certain that we can reduce the rate of silting of such reservoirs as those here described by at least 75 percent.

These observations, of course, apply only to those reservoirs whose original capacity-watershed (C/W) ratios are above the lower limiting zone below which reservoir silting cannot be controlled by soil conserving practices or land use changes (3). Reservoirs whose C/W ratios are below this zone are filled not so much by the products of soil erosion which can be controlled by soil conservation measures, as by bed load, which moves down drainage channels intermittently as a function of stream discharge. All of the reservoirs considered in this study have C/W ratios well above the lower limiting zone. Newnan Reservoir's C/W ratio of 276 acre-feet per square mile is far above the lower limit of 5 to 7 for this size drainage area. High Point's and Roxboro's ratios, both 69, are far enough above their lower limit, 10 to 20, to make the effect of bed-load sedimentation negligible.

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OUR RAINFALL

(*Continued from page* 101)

eral, high fertility is associated with increased transpiration and decreased percolation.

In conclusion, it should be emphasized that the data given in this report apply to the particular conditions involved. Differences in soil type, meteorological conditions, land use and other factors obviously will influence these values.

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Thoughtful Americans, 150 years ago, tried to encourage the control of erosion. In 1791 the Philadelphia Society for Promoting Agriculture offered, among other prizes, the following:

> For the best method, within the power of common farmers, of recovering old gullied fields to a hearty state, and such uniformity, or evenness of surface, as will again render them fit for tillage; or where the gullies are so deep and numerous as to render such recovery impracticable, for the best method of improving them, by planting trees, or otherwise, so as to yield the improver a reasonable profit for his expenses therein, founded on experiment — a gold medal; and for the next best — a silver medal.

Classics in the Soil Conservation Field

WILLIAM R. VAN DERSAL

DR. VAN DERSAL, Regional Chief of the Division of Operations for the Pacific Region of the Soil Conservation Service, is located at Portland, Oregon. He is the author of the *American Land* and co-author of *The Land Renewed.*

This article was written in response to an editorial that appeared in the October, 1946, issue of the JOURNAL.

THERE ARE a number of books in the field of soil conservation that deserve to be known as classics. These books are, as the dictionary puts it, "of highest rank." Some of them were published only recently; others were published a long time ago. But all of them contain ideas and points of view that should be familiar to every professional soil conservationist.

Just how many soil conservation classics there are at the present time is a matter of opinion. The judgment of experienced soil conservationists, as one might expect, varies considerably on this point. During the past several years I have asked many people to give me their best list of works that are entitled to a place among the very best. Most of the lists differ by one book or several from other lists, but even so there are a few books that are nearly always mentioned. Opinions came from professional soil conservationists in many parts of America, as well as from librarians, specialists, and others. These opinions, when put together, agree fairly well on the following group:

1 *The Earth as Modified by Human Action* by G. P. Marsh. 1884. (Last issued by Scribner, New York, 1907. 629 pp.)

This book seems to be out of print, and it appears only rarely in second-hand bookstores. It is in this work that the first estimate of world land destruction from erosion appears in print. Marsh put this at a "territory larger than all of Europe," which would amount to about two million square miles. His historical evidence makes fascinating reading. Undoubtedly this book will be reprinted sooner or later, but at present the library is about the only place where it can be obtained.

2 *Holy Earth* by L. H. Bailey, 1915 (Reprinted in 1943 by Christian Rural Fellowship, 117 pp.)

The recent reprinting testifies to the lasting value of this work. Liberty Hyde Bailey is possibly best known for his horticultural books, such as the *Standard Cyclopedia of Horticulture, Hortus,* and others. But he has written a great deal about land use, rural living, and agriculture. You can still buy *The Holy Earth* for twenty-five cents from the Fellowship at 156 Fifth Avenue, New York City.

3 *Soil Exhaustion as a Factor in the Agricultural History of Virginia and Maryland,* 1606-1860 by R. O. Craven. (Univ. Ill. Studies in Soc. Sci. Vol. 13, No. 1, 178 pp.) Urbana, 1925.

This is excellent reading and an important study for use everywhere. It does much to show how soil depletion shapes agricultural development of a region, as well as the larger social-economic order. Possibly it is still available at the University of Illinois for a dollar and a half. If not, you can get it at the library.

4 *Soil Erosion a National Menace* by H. H. Bennett and W. R. Chapline. U.S.D.A. Circ. 22. 36 pp., illus. 1928.

This circular is now out of print but it stands as a landmark in the soil conservation movement. It did much to crystallize public sentiment on the necessity for action in the United States. While it contains little that does not appear in later works (as No. 8 below) it is well worth reading in the light of the times in which it was published.

5 *Deserts on the March* by Paul B. Sears, 231 pp., illus., Norman, Oklahoma, University of Oklahoma Press, 1935.

The book that helped to convince the American public of the need for action in the Dust Bowl. It treats much more than wind erosion, and is particularly well written. It is still in print and can be ordered at your bookstore.

6 *Rich Land, Poor Land* by Stuart Chase. 361 pp., illus. (incl. maps). New York, McGraw-Hill, 1936.

Here is a book that contains an inventory of the land situation in this country that will eventually be superseded, but still stands as the best, or one of the best we have. Dramatically written, as Stuart Chase usually writes, and very easy reading. The book is still available from the publishers.

7 *The Rape of the Earth* by G. V. Jacks and R. O. Whyte. 312 pp., illus., London, Faber, 1939.

This magnificent book was republished in this country by Doubleday, Doran and Company in 1939 under the title of *"Vanishing Lands."* For an unexplained reason some 60 pages of material and a number of plates were omitted that appeared in the English version. Even so, the American edition is very nearly as good. Both books are out of print.

The book contains the second world-wide estimate (see No. 1) of erosion damage. It is up to date, well documented, and fairly easy reading. Unquestionably a "must" for every soil conservationist, and available at most libraries. Possibly enough inquiries at Doubleday might result in a reprint; or perhaps one of these days the Society might take this up as a worthwhile project.

8 *Soil Conservation* by H. H. Bennett. 993 pp., illus., New York, McGraw-Hill, 1939.

If you could afford to own only one book on soil conservation, this is the one you should get. It is heavy going in places, and is more properly a reference work than one to read for pleasure. The wealth of information in it is astounding, and it covers every phase of the subject including the historical.

This and *Rape of the Earth* easily head any list of important books on soil conservation. Bennett pays greatest attention to the United States; Jacks and Whyte write about the whole world. Taken together they form a near-complete library in themselves.

9 *Early American Soil Conservationists* by Angus McDonald. U.S.D.A. Misc. Publ. 394, 63 pp., illus. 1940.

A few copies of this publication are still available. There are some things in this bulletin that do not appear in group 8, although about the same material went into both. It is well worth owning for the story of the development of soil conservation ideas in this country.

10 *This Land We Defend* by H. H. Bennett and W. C. Pryor. 107 pp., illus., New York, Longmans, 1942.

A simple, straightforward story of erosion in the United States and what's being done about it. A popular work on soil conservation written for easy reading. Topnotch pictures.

11 *Soil Erosion in New Zealand* by K. B. Cumberland. 227 pp., illus., with maps. Issued by the Soil Conservation and Rivers Control Council. Published by Whitcombe and Tombs, Wellington, 1943.

This is probably the best survey report ever published on the land situation of any country. It is very little known, and until 1945 there were probably no more than three copies in this country. Presumably it can be purchased from the publishers in New Zealand. The U. S. Department of Agriculture library has at least one copy and by now, possibly more. Valuable portions of the book have appeared in the Geographical Review (31:529-554, and especially 34:77-95 which contains a few of the pictures).

12 *Natural Principles of Land Use* by Edward H. Graham. 274 pp., illus. New York, Oxford University Press, 1944.

A whole new approach to land use is covered in this volume. In it the author successfully

SEND TODAY for this catalog. It lists and describes the movies, booklets, slide films, wall posters, charts, etc., comprising Case "Visual Education Materials." It also tells how to secure supplies of printed items and to schedule the loan of films. Address Educational Division, J. I. Case Co., Racine, Wis.

Created to Help You Sell Soil Conservation

● Here are powerful pieces of ammunition for your campaign to push soil conservation beyond the realm of academic acceptance into the living world of everyday farming. They portray conservation with all the dynamic suggestion of actual procedure and tangible results. Because they inspire and instruct farmers in advanced practices with their own farm tractors and implements, they implant the idea of conservation as a way of normal farming.

Titles of a few educational booklets shown above will suggest the scope of Case materials available. Most of them have parallel films of similar title and subject matter. Some are supplemented by wall posters or charts suitable for exhibits at meetings, and for lecture-study use. In all, the purpose is to be simple, clear, vivid.

Case movies on soil conservation and related practices embody tested methods in detail. They are all in the 16 mm. width, in full color and sound. With their companion booklets for detailed study and permanent reference, they provide both initial stimulus and a follow-through. You are invited to use them.

CASE

brings ecological principles to bear on land problems. A practical, fresh point of view destined to be of increasing importance in the land use field.

13 *Food or Famine* by Ward Shepard. 225 pp., illus., New York, Macmillan, 1945.

Shephard deals in a challenging way with the question of what we are going to do about erosion. It is packed with ideas with which you may not agree, but nevertheless important and fundamental.

14 *Man and the Soil* by Karl B. Mickey. 110 pp. International Harvester Co., Chicago, 1945.

An easily-read, simply written story offered by the International Harvester Company, and still available free from their public relations department. It is unusual for a commercial concern to put out a book, and even more so to put out such a good one.

There are a great many more books that could appear on this list. Personally, I should like to see it contain Russell Lord's "*To Hold This Soil*" and C. F. S. Sharp's "*What Is Soil Erosion.*" I think Stanley Gaine's "*Bibliography of Soil Erosion and Soil Conservation,*" while not a book to read, is an important milestone of the science. Gustafson's *Conservation of the Soil* is a textbook—still the only thing of its kind in this wide-open field. The new "*Population Roads to Peace or War*" by G. I. Burch and Elmer Pendell is worth any soil conservationist's time. And so on.

Undoubtedly this list of classics will change as time goes on. Probably it will be changed at once by many who disagree with the choices. But it seemed worthwhile to publish it as a suggestion to the man seeking to gain or hold professional status.

It has always seemed pretty clear that a professional worker must read a great deal if he hopes to maintain his standing. He must keep up with current literature of his own as well as foreign countries. Likewise he must also read to gain historical perspective, as the editor of the JOURNAL pointed out in the second issue. If ever the time comes when a professional man lags in his search for new ideas and his striving for a broader understanding of his field, disaster is about to overtake him. Habitual self-teaching is a downright necessity for any soil conservationist not actually going to school. After graduation a professional man either advances in his field—or he stagnates. Good reading can do much to prevent the latter.

FOREST HYDROLOGY

(*Continued from page 76*)

be overcome by adopting soil restorative measures as a common practice for cut-over areas along with reforestation, slash disposal, stand improvement, and other comparable practices.

Coweeta is demonstrating that water problems can be solved and that specific management of forest lands in the interest of the water resource is possible. We now know the effects of certain forestry measures and have indications on others. By opening the hydrologic door, the Coweeta Experimental Forest is helping us to understand the problem and to stimulate our thinking on solutions.

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"The late rain had in many places washed away great pieces of the ground sown with wheat and rye." So wrote Peter Kalm, a Swedish botanist traveling in New Jersey, in the year 1749.

They Keep the Land Where It Belongs

Charles Murray, New Cumberland, West Va., gives the corn on his 118-acre Hancock County farm a first cultivation with his Farmall A.

Same field, last cultivation. Mr. Murray planted corn and hay in alternate strips in one section; oats and hay in alternate strips in another.

Farming on the contour helps hold the soil, farmers in the rugged West Virginia Northern Panhandle agree.

160 Farmers in Hancock County, West Va., Put 2,500 Hilly Acres in Strip Crops

Approved soil conservation practices have come to stay in the rugged West Virginia Northern Panhandle.

Some 160 farmers in Hancock County, far up along the western Pennsylvania borderline, have close to 2,500 acres in strip crops, and between 25,000 and 30,000 feet of diversion terraces have been constructed above the strip-cropped fields. Much worthwhile work has also been done in pasture improvement, terracing, reforestation, construction of ponds for watering of stock and propagation of fish, and building game refuges.

These farmers, with the splendid help of the United States Soil Conservation Service, are learning to get the most out of their steep and sloping land. *They are keeping the land where it belongs.*

* * *

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BOOK REVIEWS

CONSERVATION OF CHILEAN SOILS. By Manuel Rodríguez Zapata and José Suárez Fanjul, Department of Genetics and Plant Technology, General Direction of Agriculture, Ministry of Agriculture. Santiago, Chile. 1946. 79 pp. 14 halftone plates.

LA CONSERVACION DE LOS SUELOS DE CHILE—por Manuel Rodríguez Zapata y José Suárez Fanjul. Ilustrado con fotograbados. Departamento de Genética y Fitotecnia. Dirección General de Agricultura, MINISTERIO DE AGRICULTURA, Santiago de Chile, 1946.

IN 1942 AND 1943, the reviewer had the privilege of helping to introduce two alert young Chileans to the problems and processes of soil conservation in the United States. Rodríguez has since become Chief of the Section of Soil Conservation of the Department of Genectics and Plant Technology, and Suárez is Chief of the Section of forage plants of the same Department. They have turned out an extremely creditable booklet, interesting, not only in the picture it shows of the gloomy erosion situation in Chile, but also because of the insight it gives into the opinion of two intelligent foreigners on the soundness and success of soil conservation work in the United States.

The booklet contains a prologue by Manual Elgueta Guerin, Director of the Department, and six chapters. The first chapter (Natural resources) lists various types of natural resources and the ecological relations between some of them, distinguishes between non-renewable and renewable ones, and emphasizes the dependence of the renewable ones on the soil. This chapter contains the first of several quotations from Claudio Gay, who was writing—in Spanish—about 110 years ago in exactly the same vein as W. C. Lowdermilk or Lyle F. Watts on the erosion and destruction of agriculture caused by depleting the forests. The reviewer had never before heard of Gay, but he would like to hear a great deal more, and hopes the Editor will arrange to have Rodríguez or Suárez or both write an article on him for the JOURNAL.

Chapter two (Soils and erosion) defines erosion, and gives some figures on its progress in Chile. Chile has an area of 74,000,000 hectares, of which 26 percent (about 1/5 seriously eroded) is suitable for agriculture, and 16 percent is in forest soils. In the central coastal section of Chile, sheet and gully erosion have destroyed thousands of hectares. A large part of the hilly area of this section has lost from half to all its topsoil. Production of wheat in the quinquennium 1935-40 was about 20 percent below that of 1910-15. There are about half a million hectares of sand dunes formed largely, and since Gay's time, from eroded material washed down the short, rapid rivers, spread along the coast by the sea, and blown inland by the wind. In the extreme south, overgrazing has allowed wind erosion to start.

The third chapter (Is soil conservation possible?) is perhaps the keystone of the booklet, and explains and emphasizes—by skillful presentation and bold-faced type — the concept of proper land use. Among practices urged are proper pasture management, crop rotations, woodland management and fertilization. Among practices warned against are single cropping, overgrazing, clearing woodland by fire, and "subjugating for crops land suitable only for permanent use as pasture or woodland." The problem of getting good land use on farms too small to be economic units is also discussed.

Chapter four (Protection of our lands) begins to outline a program for conserving Chilean soil. Afforestation has already made notable progress, since more than 140,000 hectares have been planted—60 percent to pines and 30 percent to Eucalyptus—by the Department of Forestry of the Ministry of Lands. In some sections this has completely stopped serious erosion, and some of the dune areas have been stabilized and reclaimed. The authors have three faults to find with this program: 1. Some perfectly good agricultural lands, which Chile can ill spare, have been afforested; 2. the work is not sufficiently

An apple that is diseased at the core, is not a good keeper!

If you regard soil depletion as a form of spoilage, then this great country has been slowly deteriorating at the core. The heart of America, the very foundation upon which it rests, is its agricultural land. Even casual observation tells us we have ruined a considerable acreage. Soil conservation scientists set the figure at approximately a hundred million acres for cropland alone. But, many more millions of acres have been seriously damaged.

Another way of saying the same thing: We are still ruining land faster than we are saving it. We aren't even holding our own—yet. You—the members of the Soil Conservation Society of America—know such things and are trying to tip the scales.

MOVIES MAY HELP YOU

If you need educational motion pictures on soil conservation, perhaps John Deere's new sound movie, "Soil Conservation with Regular Farm Equipment," will help you. Why not order a print for showing at your educational meetings? The film runs 20 minutes and is offered free of charge, other than the cost of transportation. Available in 16 or 35mm. Send your request for the film to John Deere, Moline, Ill.

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integrated with the agricultural program; and 3. because of lack of funds, afforestation of eroded lands has been too slow and too limited. Agricultural experimentation has been begun, but much more is needed, especially in the fields of rotations, pastures, fertilizers, tillage, measurement of erosion, and afforestation. A good, but very small, start has been made in conservation surveys. The need for working directly with farmers is stressed, and the start made in this direction is outlined.

The fifth chapter (Program for a permanent agriculture) proposes specific steps, legal and otherwise, to carry out the suggestions already made, and introduces some subjects scarcely touched on before, such as the necessity for rational use and perpetuation of the vast areas of native forest on soils unsuited for other use; necessity for the state to purchase holdings too small to tbe economically practical under a permanent system of agriculture, and to resettle the owners elsewhere. The legal basis of the Soil Conservation Service and of the soil conservation districts is given in some detail, although soil conservation districts on the U. S. pattern are not specifically recommended for Chile. Finally described is the direct and indirect destruction of agricultural land by placer mining. The mining laws of Chile seem to be as little concerned with agriculture and forestry values as those of California. Chapter four (Conclusions) contains a brief summary.

Two omissions from the booklet call for some comment. The authors mention no doubts they may have as to the desirability of afforesting exclusively with North American (practically all the pines are Monterey Pines) and Australian species. Chile has some extremely valuable native trees, both hardwoods and conifers, that should surely be better than exotics for some of this work. The other omission is in the treatment of conservation surveys. These are apparently being made on the basis of soil types and series, and no mention is made of the land use capability concept which has proved so valuable in the United States. The reviewer holds no special brief for eight capability classes rather than some other number, nor for the precise definitions now in use here, but the idea of grouping soils having common hazards and common limitations in safe use is so basic that I would expect the "direct action with farmers," urged by the authors, to be difficult without this tool.

There is no index; citations to literature are given only in footnotes; the excellent photographs are rather poorly reproduced; and the stapled binding makes the booklet difficult to open. The paper is good and the make-up and printing are clear and attractitve; the only typographical error I found had already been corrected by pen. The authors are to be congratulated on an excellent performance.

—R. M. BOND.

CITIES ARE ABNORMAL—Edited by Elmer T. Peterson. University of Oklahoma Press. 1946. 263 pp. $3.00.

THE SOIL conservationist knows that agricultural activities are closely related to urban affairs. This collection of 14 essays treats some phases of the relationship.

The population scholar, Warren S. Thompson, writes two chapters. First, he points out that only within the past 150 years have we been able to control sanitation well enough to permit the natural growth of large cities. More than half the people in the United States now live under distinctly urban conditions, where a birth deficit exists requiring that, for every child born in urban areas, two must be born in non-urban areas if we are to maintain our recent birth rate. In another chapter Thompson states that eleven of our metropolitan areas, each having more than a million people, embrace a quarter of our entire population. He claims that our only defense against atomic bombs is dispersal, and he suggests a type of protective city plan, although he recognizes that our real hope is not in the design of cities but in a new world political

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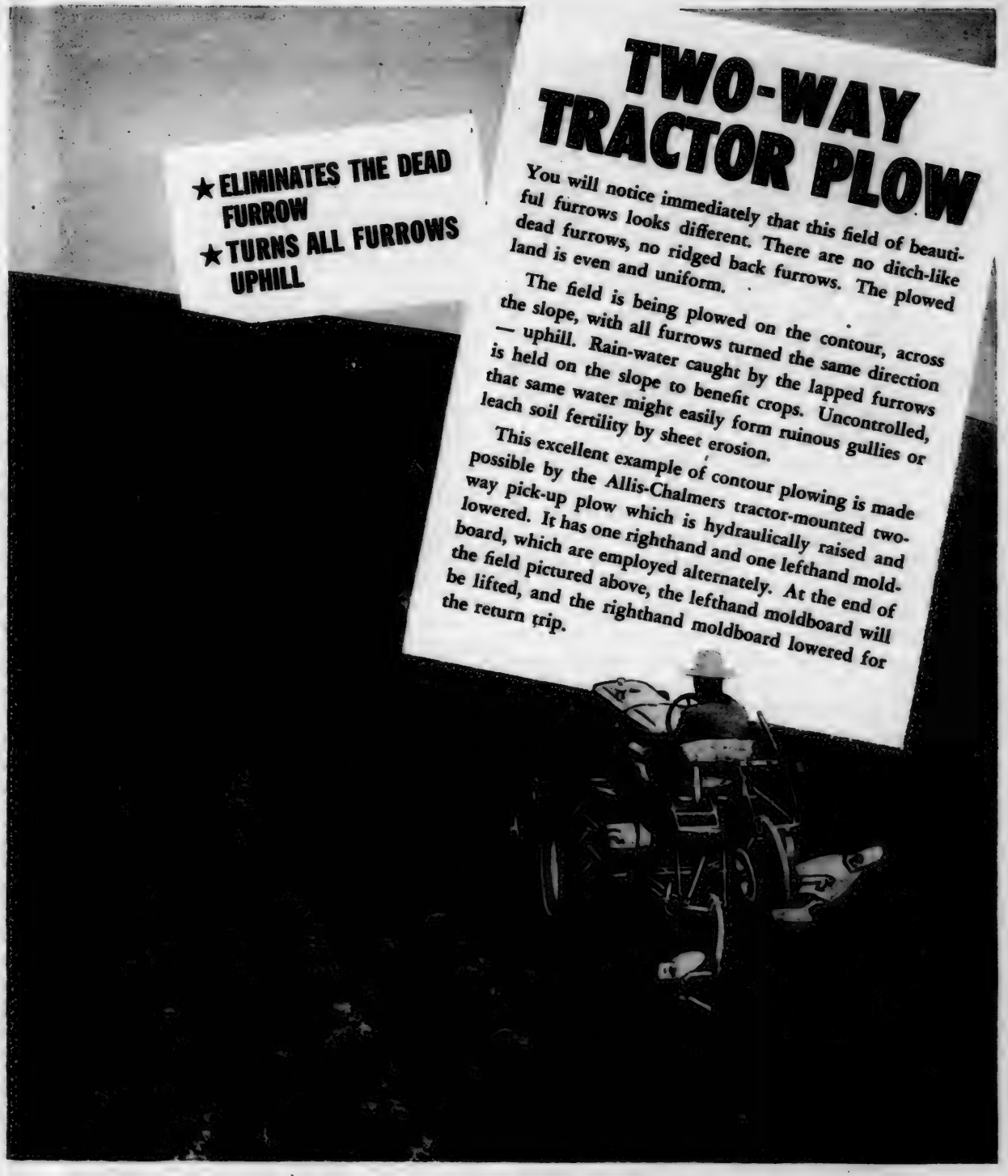

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Social scientist Paul L. Vogt also points to the concentration of population in industrial areas, but he contends that manufacturing in the United States is still in its infancy, with development to come in small and medium-sized centers of industry. Jonathan Forman, in one of the book's most instructive essays, discusses biological facts, such as the effects of noise, contaminated air, poor ventilation, frustration, "rooming-house schizophrenia," and other mental ills of cities.

Paul B. Sears writes well of the place of man in the natural scheme of things. He makes some philosophical points, and states that the human community, like that composed of plants and animals, must have a favorable energy budget. As an architect, Henry L. Kamphoefner calls for organic planning of cities, with decentralized shopping areas, a factory on broad acres with scattered attractive houses, and many quiet streets. Sociologist J. J. Rhyne calls for diversification in business and industry. He makes a good deal of the fact that the number of relief workers during the last depression was proportionately large in large urban areas, the only exceptions being where soil erosion and drought were severe.

The chapter by S. C. McConahey recounts our change from 10 percent urban population in 1790 to 85 percent in 1945. Based upon free enterprise, he calls for part-time factory work while living on the land. H. C. Nixon thinks we need to strengthen our country and other local governments, and Roy L. Smith, while acknowledging the debt of culture to cities, believes that regional cultures, like that of our midwest painters, would provide vast new outlets for the creative arts.

Louis Bromfield compares the security of the Frenchman, by nature a landholder, with the unstable lot of the American, always in debt for his wages. There is a stimulating chapter by Ladd Haystead, predicting the farmer's condition in the years ahead, when he will have new gadgets of all kinds and rural industry will develop with ready and cheap electric power. Haystead contends that processing of agricultural products should be done near the point of production, and he holds that mechanization can be advantageous to farm life without ruining the soil.

Elmer T. Peterson has edited the book, written the foreword, the introductory and concluding chapters. The war disclosed we are only a short step ahead of starvation, even in this productive land. Peterson questions some of the things on which we pride ourselves and places soil conservation as the first of several things we need to do if we are to survive. "It should be remembered that when the soil goes, so also goes urban industry, business, the professions—everything."

Cities Are Abnormal reflects in its title its intended theme, but eleven authors writing about a subject cannot easily develop a single idea. The book does not forcefully make any particular point. Much of the material does not relate to the title. Nevertheless, it is a consideration of a serious subject of the day, and will probably be read along with Borsodi, Mumford, Wright, Hilberseimer and other students of cities—their growth, significance, and the solution of the problems they present.

—EDWARD H. GRAHAM

New Books Received

Some of the books listed in this section are to be reviewed in future issues of the JOURNAL. An effort will be made to cover all fields of conservation from time to time in so far as complete reviews are concerned.

THE RUFFED GROUSE by Frank C. Edminster is a discussion of the life history, the habitat requirements, characteristics, and management of this fine game bird. The book is well illustrated with numerous photographs, charts, and tables. MacMillan Company, New York. 1947. $5.00.

THE LAND AND WILDLIFE. This book, written by Edward H. Graham, is a guide to the

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Once gullies have become so large that the cost of filling exceeds the value of the land, it is better to stabilize them in some manner; but when a gully like the one in the upper photograph is eating its way across valuable cropland, it is well worth the effort and expense to transform it into a vegetated waterway.

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We would welcome the opportunity to tell you more about the many uses of the modern Power Grader in Soil and Water Conservation.

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management of wildlife by means of land use. It deals with those land-use practices that have been found to be most beneficial to wildlife; it describes each practice, how it fits into schemes of wise land management, and what it means to wildlife, a term used throughout the book in a restricted sense to mean wild vertibrate animals, chiefly fish, birds, and mammals. Oxford University Press, New York. 1947. 232 pages.

THE LORD'S LAND is a 26-page booklet designed especially for the use of clergymen and other religious workers. It was written by Morris E. Fonda of the Soil Conservation Service and published by The Sears-Roebuck Foundation, Chicago, Illinois. The following quotation from the foreword gives the theme: "There can be no separation of man from the land—his whole existence is tied to the soil—from the beginning of his days to the time his body is laid to rest in the arms of the earth. From the busiest corner on the modern city to the windblown country fields, human livelihood is a product of the land . . . ."

THE FARM IN THE FEN. For centuries the Fens have been the scene of a struggle between man and water. Man has become the victor by harnessing the water and has wrested from it the most fertile tract of land in England. This book, by Alan Bloom, records how bad drainage hampered almost every effort to produce food needed during the war. It tells how water, bushes, reeds, turf pits, and bog oak had to be dispersed before food could be produced. Faber and Faber, 24 Russell Square, London. 1944. 192 pages. 10s 6d.

CONSERVATION IN THE UNITED STATES by A. F. Gustafson, C. H. Guise, W. J. Hamilton, Jr., and H. Ries, members of the Faculty of Cornell University, present a nontechnical discussion of facts concerning the conservation of natural resources in the United States. The book is a second edition. It recognizes the importance of changes in the American way of life and that new developments in the conservation of our resources will take place; also the imperative need for their wise use. Comstock Publishing Co., Inc., Ithaca, New York. 1945. 477 pages.

Educational Films

John Deere has produced and offers for use a new sound motion picture film, "Soil Conservation with Regular Farm Equipment."

The film is available in either 35 mm. or 16 mm. black and white and in 16 mm. in color, all with sound. Dealing with various soil conservation practices, it has been prepared as an educational film and may be obtained through the Advertising Department, Deere & Co., Moline, Ill. The user is asked to defray only the costs of transportation.

"We returned from St. Simon's to Hopeton, much pleased with our expedition. As our canoe was scudding through the clear waters of the Altamaha, Mr. Couper mentioned a fact which shows the effect of herbage, shrubs, and trees in protecting the soil from the wasting action of rai nand torrents. Formerly, even during floods, the Altamaha was transparent, or only stained of a darker color by decayed vegetable matter, like some streams in Europe which flow out of jeat moss. So late as 1841, a resident here could distinguish on which of the two branches of the Altamaha, the Oconee or Ocmulgee, a freshed had occurred, for the lands on the upper county, drained by one of these (the Oconee) had already been partially cleared and cultivated, so that that tributary sent down a copious supply of red mud, while the other (the Ocmulgee) remained clear, though swollen. But no sooner had the Indians been driven out, and the woods of their old hunting-grounds begun to give way before the ax of the new settler, than the Ocmulge also became turbid." ("A Second Visit to the United States of America," 1849, Vol. 1, p. 256.)

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